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**CAN THE AIR FORCE SOLVE ITS
SPARES FORECASTING PROBLEM?**

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Executive Summary

CAN THE AIR FORCE SOLVE ITS SPARES FORECASTING PROBLEM?

The credibility of Air Force estimates of future spare parts requirements has suffered a great deal in recent years. Radically changing estimates for the same year are one of the main reasons. Since 1982, for example, official Air Force estimates of the FY87 requirement have changed, either up or down, by roughly \$1 billion a year. Changes in the planned operating program are not enough to explain the variations.

The Air Force Logistics Command (AFLC) has developed a regression model, the Air Logistics Early Requirements Technique (ALERT), to improve Program Objective Memorandum (POM) forecasts of funding requirements for reparable spares. ALERT attempts to predict the output of the D041 Recoverable Item/Central Secondary Item Stratification (CSIS) system, the Air Force procedure for computing and executing reparable spares budgets. ALERT uses an early, "first look" D041/CSIS estimate of the first POM year's requirement as a key input for projecting what the D041/CSIS "last look" will be. Other inputs include age and value of the aircraft fleet, which serve as additional predictors, and D041/CSIS budget estimates, which serve as "history" for the 2 years preceding the first POM year.

In spite of its conceptual appeal, we do not think ALERT *by itself* can solve the credibility problem for spares requirements. The system upon which ALERT relies for key inputs, the D041/CSIS budgeting system, is too volatile, making it virtually impossible for ALERT to achieve the stability and accuracy needed for credibility. From FY81 to FY85, for example, D041/CSIS budgets differed from D041/CSIS last looks by at least \$800 million for each of those 5 fiscal years. Given this volatility in the underlying D041/CSIS system, it is not surprising that ALERT outputs are

unstable. Successive ALERT estimates of the FY88 requirement, for example, have been: \$5 billion (spring 1984), \$3.4 billion (spring 1985), and \$2.2 billion (fall 1985).

As a test of ALERT's accuracy, we used it to make a "projection" of a known historical value, the last look for FY85. Using inputs that would have been available at the time, the ALERT projection is \$3.8 billion. This overstates the actual last look for FY85 by \$1.5 billion — an error of 65 percent.

Since ALERT represents a reasonable attempt to link POM forecasts with the underlying D041/CSIS budgeting and execution system, improvements in ALERT results are unlikely until the volatility in the D041/CSIS system is reduced. Improving the D041/CSIS system is itself a formidable task. Key to its accomplishment is the Requirements Data Bank (RDB) project now underway at AFLC. By providing improved access to and control of the spares data base, the RDB is aimed at improving AFLC's ability to compute spares requirements and execute the spares program. For the RDB to help with POM and budget forecasting, however, the Air Force must also be prepared to use the RDB to actively *manage* the requirement, in addition to computing it. Some changes in requirements are unavoidable, but many reflect judgments, decisions, and schedules that could be altered or adjusted in the interest of requirement stability. A key role for the RDB is to facilitate this improved management.

It is also important for the Air Staff and AFLC to each maintain a clear view of the other's job. Recognizing that requirements for recoverables will always exhibit some volatility and that the requirements system must be able to track change if AFLC is to execute properly, the Air Staff must allow AFLC as much flexibility as possible. AFLC, on the other hand, should recognize that the requirements estimates it submits to the Air Staff need to be relatively stable if the Air Staff is to successfully defend requirements in the programming and budgeting process.

Whether or not reparables are stock-funded, successful POM forecasting is more likely to be achieved through closer cooperation between AFLC and the Air Staff in developing, prioritizing, and controlling spares requirements than through development of increasingly more complicated forecasting techniques.

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1. INTRODUCTION

Each May, at the end of the DoD programming cycle, the Air Force and other Military Departments submit Program Objective Memorandums (POMs) to the Office of the Secretary of Defense (OSD). The purpose of POMs is to formally identify requirements and aid in resource allocation in the DoD. POMs contain estimates of the funding needed over a future 5-year period that begins 2 years after the POMs are submitted. In May of 1986, for example, the Air Force submitted POM 88, which described funding needs for the period FY88 through FY92.

As part of the programming process, the Air Force must develop estimates of the aggregate funding needed in each of the 5 POM years to replenish and augment peacetime operating stocks (POS) of depot-level-reparable secondary items, i.e., spares.¹

After POMs are submitted, the first year of the 5-year POM period becomes the budget year. For example, after submitting POM 88 for the years FY88 through FY92 in May 1986, the Air Force finalizes a budget for FY88 and submits it to OSD in October 1986. Like a POM, a budget must include a statement of the funding needed for replenishment of POS spares.

For smooth allocation of resources, POM and budget estimates of aggregate spares requirements should be about the same. However, there is an important difference in the Air Force between programming and budgeting for spares. For

¹In this study, we discuss only POS requirements, which constitute the bulk of recoverable secondary item requirements [e.g., \$2.6 billion out of a total spares requirement of \$3.8 billion in FY87 — for both POS and War Reserve Materiel (WRM)]. The Air Force projects WRM requirements by means other than those used for determining POS requirements. WRM requirements tend to be for "kits" and "sets" based upon specific acquisition, basing, and deployment programs. POS replenishment requirements are driven more by historical demand, future operating activity, changing pipeline factors, additives, and modification and modernization programs.

budgeting, the Air Force begins with "bottom-up," item-specific calculations of gross item requirements and projected asset positions. The difference between gross requirements and available assets is priced, accumulated over all items, and stratified to show how assets have been applied and where net requirements still exist. (DoD supply policy for secondary items *requires* bottom-up, item-specific stratification.) After stratification, the Air Force makes management adjustments — at both the item level and the program level — for final preparation of a budget. POMs are different. For POM estimates, the Air Force does not begin with item-level calculations, but, instead, uses methods that are more top-down and "macro" in concept.²

This report addresses spares programming in the Air Force. It does so in the context of an evaluation of ALERT (Air Logistics Early Requirements Technique), a macro, weapon-system-level procedure developed by the Air Force Logistics Command (AFLC) for forecasting reparable spares requirements for POMs. The credibility of Air Force estimates of future spares requirements has suffered a great deal in recent years. ALERT represents an attempt to address the problem by improving POM forecasts for spares.

Our first main conclusion is that ALERT will not solve the credibility problem for Air Force spares requirements. ALERT will not be able to deliver the stable and accurate forecasts that are needed. The reasons lie not so much with ALERT itself as with the underlying, item-specific budgeting and execution system, the D041/CSIS/transition system. "D041" is shorthand for the Recoverable Consumption Item

²The longer length of POM forecasting horizons compared to those for budgets, particularly for the POM outyears, makes item-specific methods for POMs impractical. Item-level data are not always available. Even when they are, the logistics factors for secondary items (e.g., failure and demand rates, repair and resupply times, condemnation rates, application levels in the fleet, and obsolescence rates) change so much over time that item-specific projections become unreliable. (In fact, we will see that even though budgets have shorter forecasting horizons, they suffer from the same problem, further complicating the forecasting problem for spares.)

Requirements System. CSIS stands for Central Secondary Item Stratification. "Transition" refers to the management review and adjustment process that follows item-specific computations. The D041/CSIS/transition process is the means by which AFLC determines and establishes what the spares requirement is — both for budgets and for execution. POM forecasts are forecasts of future results of the D041/CSIS/transition system.

Our second main conclusion is that unless D041/CSIS/transition-based estimates of future requirements can be made more stable and accurate, the credibility problem for spare requirements will persist — no matter what POM forecasting methods the Air Force may develop. This is because the credibility problem is caused far more by persistently large differences between budgets and final execution requirements for spares — a problem caused by defects in the budgeting system — than by poor POM forecasts.

A final chapter points out various *management* actions the Air Force can take to deal with the spares programming problem, rather than continuing to seek technical solutions in the form of forecasting models. The chapter describes how taking these management actions would mitigate the credibility problem for POMs and allow the Air Force to concentrate on the more fundamental and important problem of forecasting budget requirements for spares.

2. UNDERSTANDING THE PROBLEM

THE CREDIBILITY PROBLEM

The problem facing the Air Force in its estimates of future spares requirements is both technical and perceptual. The technical part of the problem has to do with structural and technical difficulties involved in forecasting future funding requirements for spares. The perceptual part of the problem has to do with the fact that many people simply do not believe Air Force forecasts of those requirements – regardless of how they are constructed. Ultimately, it is the latter problem, the credibility and defensibility problem, that is the real problem to be solved. To be useful, technical forecasting methods and models should help make projected requirements more credible and defensible in the programming and budgeting process. To properly evaluate forecasting methods and determine their chances of success, therefore, we must first understand who has a problem with spares forecasts and why.¹

Concern about estimates of future Air Force spares requirements exists both within and outside the Air Force. Externally, in the course of annual DoD Planning, Programming, and Budgeting System (PPBS) reviews, considerable skepticism about spares requirements has surfaced within OSD. In February 1986, for example, acting on concerns raised by the Program Analysis and Evaluation Directorate and

¹Ongoing controversies about secondary item prices, particularly for *consumable* repair parts, have exacerbated the forecasting problem. In addition, the Air Force has numerous initiatives underway (such as competition advocacy and breakout programs, changes in contracting and ordering procedures, and re-pricing programs) that will affect forecasts of future funding requirements for spares. The *pricing problem* for spares, however, is not the central topic of this report. We are concerned with the problem of *requirements forecasting* overall – of which pricing is only a part. Also, our analysis is only for *nonconsumable*, depot-level-reparable secondary items [items with Expendability, Recoverability, Repairability Category (ERRC) code: XD]. Later, we will say more about how changing prices contribute to the forecasting problem.

the Assistant Secretary of Defense (Acquisition and Logistics), the Deputy Secretary of Defense notified the Secretary of the Air Force that "the Air Force spares forecasting methodology will be looked at critically during the OSD review of POM 88."²

Concern has also been raised on Capitol Hill. In the fall of 1985, the House Appropriations Committee proposed removing \$1.3 billion from the FY86 Air Force POS replenishment spares budget, largely as a result of committee concern about the validity of the Air Force's requirements forecasts.

Internally, the Air Force has been struggling with the problem at least since the early 1980's. Several Air Force studies critical of requirements forecasting for reparableables have been published,³ and replenishment requirements have been subjected to increasingly critical scrutiny by Air Staff Panels and Boards. Ironically, ALERT seems to have done more to fan the fire than put it out. Since 1984, the Air Force Comptroller has repeatedly questioned ALERT products and methods, and flag-grade officers at both the Air Staff and AFLC have been subjected to a large number of ALERT comparisons, studies, analyses, and briefings as the controversy has continued.⁴

Why don't people believe Air Force estimates of future spares requirements? Because estimates of the same year's requirement tend to change radically from one year to the next -- giving the impression that the Air Force does not know what future spare requirements will be. Since 1982, for example, official Air Force POM

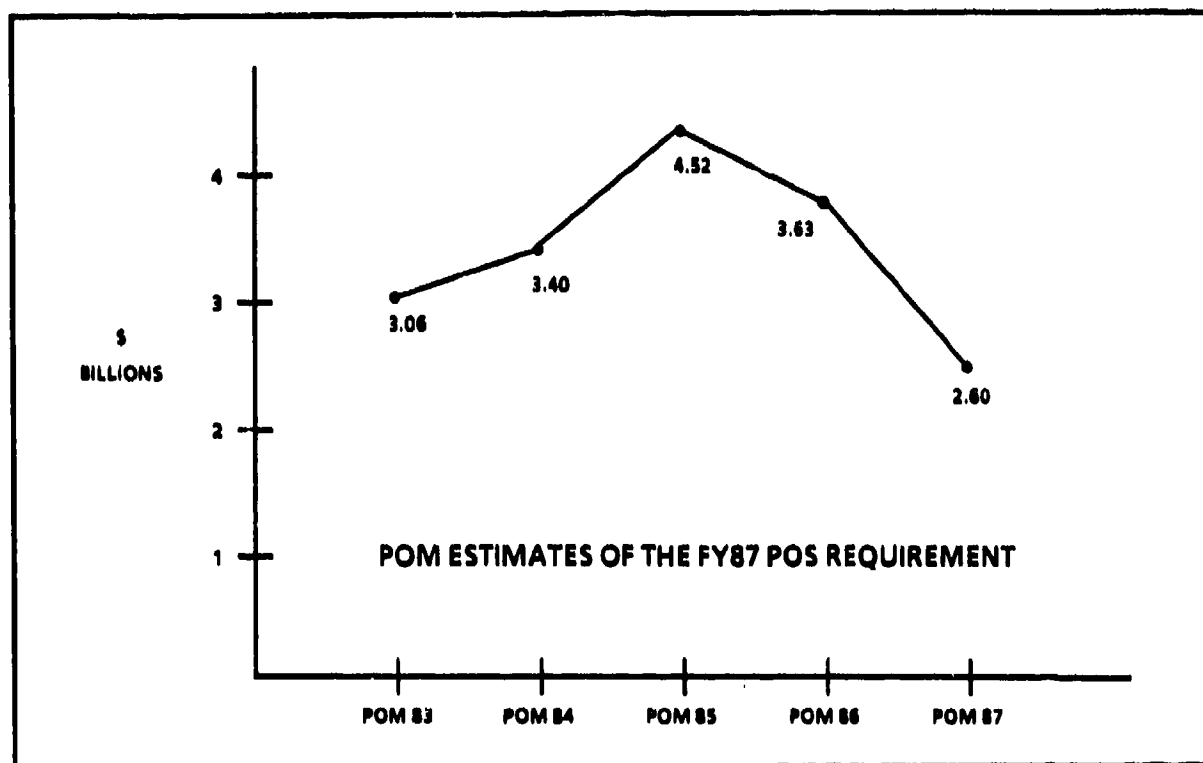
²Memorandum for the Secretary of the Air Force, Subject: "Air Force Replenishment Spares Requirements," from the Deputy Secretary of Defense, February 1986.

³See: *SABER PROVIDER - ALPHA: Programming for Aircraft Replenishment Spares* (Headquarters, U.S. Air Force: U.S. Air Force Studies and Analysis), December 1981; and *CORONA REQUIRE: An Analysis of the Aircraft Replenishment Spares Acquisition Process*, Chairman, General Alton D. Slay, U.S. Air Force (Retired), sponsored by Chief of Staff of the Air Force, March 1983.

⁴Indeed, the fact that the controversy over spares requirements has continued is prima facie evidence that ALERT cannot and will not solve the credibility problem.

estimates of the FY87 POS requirement have changed, either up or down, by roughly \$1 billion each year (see Figure 2-1)⁵.

FIGURE 2-1. THE PROBLEM OF CHANGING ESTIMATES



The problem caused by changing estimates is made clear in the February 1986 memorandum from the Deputy Secretary of Defense to the Secretary of the Air Force (cited earlier). The memorandum states that "large fluctuations in spares requirements . . . are clear indications that a credibility problem exists."

⁵The Air Force has changed its POM forecasting methods for POS requirements over the time period addressed in Figure 2-1. The estimates in POM 83 and POM 84 were based on a cost-per-flying-hour method. The estimates in POM 85 and POM 86 were derived from the POS Spares Estimating Model (POSSEM), developed by the Air Force Comptroller. The estimate in POM 87 was derived from ALERT. Although the use of different models explains some of the fluctuation in the estimates, this does not mitigate the credibility damage that has been done. More important, there are structural reasons underlying the volatility shown in Figure 2-1, which we will see are likely to cause any POM forecasting model that relies on D041/CSIS/transition to exhibit high levels of instability — even if the same model is used from one year to the next.

How is it that POM estimates of a given year's requirement can change from year to year? There are many possible reasons.

Every year the Air Staff, AFLC, and other Air Force Commands make changes in the planned flying-hour program, modify force structure and sizing plans, and adjust schedules for modernization and modification programs. Because these changes affect future spares requirements, one cannot expect POM estimates of a given year's requirement to be *identical* from one year to the next. The problem is that these changes are not enough to explain variations as large as those reflected in Figure 2-1.

For example — as Figure 2-1 shows — the POM 87 estimate of the FY87 POS requirement was \$2.6 billion, down more than \$1 billion from the POM 86 estimate for FY87 of \$3.63 billion — a reduction of more than 27 percent. But Table 2-1 shows that neither the projected fleet size nor the planned flying-hour program changed by enough to explain such a large reduction in the requirement. (Table 2-1 shows aircraft inventory and total flying hours in FY89. FY89 is an average procurement leadtime beyond FY87, so aircraft inventory and flying hours in FY89 reflect the operating program that is supported by FY87 funding for spares.) This is not to say that either the POM 86 or POM 87 estimate for FY87 was "right." Rather, the two estimates are so different, without understandable reasons why, that the credibility of *both* estimates suffers.

It is also true that funding requirements for reparable are *net* requirements, reflecting the difference between gross requirements and available assets. As a result, a given percentage change in either direction in the planned operating program will often produce a greater percentage change, in the same direction, in the requirement. For example, a sensitivity analysis done for the Air Staff with the LMI Aircraft Availability Model shows that a 10-percent reduction in the Air Force flying-hour program planned for the period FY88 through FY94 would enable the

TABLE 2-1. OPERATING PROGRAM CHANGES UNDERLYING POM 86-TO-POM 87
CHANGES IN THE FY87 POS SPARES REQUIREMENT

USAF/AFLC AEROSPACE PROGRAM DOCUMENTS	USAF AIRCRAFT INVENTORY IN FY89	USAF FLYING-HOUR PROGRAM IN FY89 (Hundreds of hours)
PA86-1/K004 (Fall 1985)	9,158	38,685
PA87-1/K004 (Fall 1986)	9,062	37,749
Percent change	- 1%	- 2.4%

Air Force to reduce FY87 POS funding of \$2,078 million by \$305 million (a 14.7-percent reduction), without degrading aircraft support. This degree of sensitivity is not enough, however, to explain how program changes as small as those listed in Table 2-1 could produce a reduction in the FY87 requirement as large as the one that took place between POM 86 and POM 87.

Changes in estimated acquisition savings (e.g., due to increased competition), reliability and maintainability improvements, and changes in plans for modification programs will also affect year-to-year estimates of a given year's funding requirement for spares. Again, these changes are not enough to explain the large variations shown in Figure 2-1. For example, POM 86 specified a total of \$1.19 billion in class IV (reliability and maintainability improvement) modification programs for FY89. Such modification programs generate spares requirements in the form of nonrecurring demand for replacement parts. In POM 87, the FY89 class IV modification program was set at \$1.43 billion, an *increase* of \$240 million in the planned program. In general, one would expect such a change to have made the FY87 spares requirement go *up* from POM 86 to POM 87, not down as it did.

It is tempting to think that prior-year funding is another important factor influencing estimates of a given year's requirement. If year X is not "fully funded"

(i.e., the Air Force does not get what it asked for from OSD and Congress), this can have a significant effect on the next estimate of year $(X + 1)$'s requirement, due to carry-over of unfunded requirements from year X into year $(X + 1)$'s budget request. This would mean that funding decisions external to the Air Force -- which take place after forecasts have been made -- may be another reason why requirements estimates vary from year to year. This is an important point and one that must be considered when examining stability problems in the *budgeting* system for spares. It cannot be used to explain fluctuations in POM estimates, however. Outyear POM estimates are "stand-alone" estimates that assume full funding of prior-year requirements, and the first POM year can include carryover only if the Air Force itself elects not to request full funding for the (prior) budget year.

Finally, suppose that, because of the *combined* effect of the many changes between one POM cycle and the next, fluctuations as large as those in Figure 2-1 were the norm and had to be accepted as a fact of life. This raises another problem. The purpose of programming and POMs is to provide for consistent and coherent allocation of resources within the DoD planning process. To do that, POM forecasts must provide some reasonable level of accuracy. If "forecasts" of a given year's requirement can normally be expected to change by more than \$1 billion from one year to the next, allocating resources on the basis of those forecasts is a futile exercise.

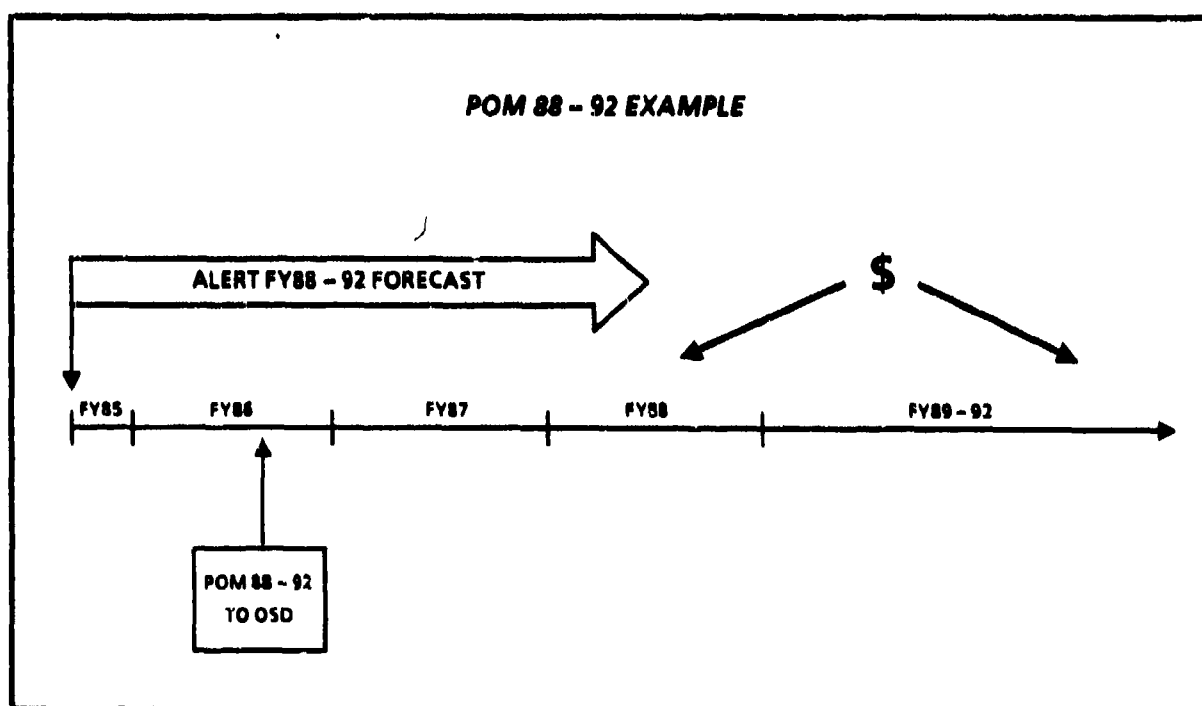
The moral is this: POM forecasting models for spares are useful in programming to the degree that they can yield reasonably stable estimates of future requirements -- estimates that recognize there will always be some change from one year to the next, but also recognize that too much change (independent of major program changes) is self-defeating.

TECHNICAL ASPECTS OF THE PROBLEM

As noted earlier, there are technical and structural difficulties involved in forecasting spares requirements for POMs. These difficulties are separate from, but contribute to, the credibility problem. This section describes the technical and structural characteristics of the forecasting problem for spares.

Figure 2-2 illustrates the forecasting problem for POM 88. POM 88 serves as an example throughout the remainder of the report.

FIGURE 2-2. THE FORECASTING TIMELINE



The POM forecast for FY88 illustrated in Figure 2-2 is actually the last in a sequence of five POM forecasts in which FY88 requirements were included. The first was POM 84, which was submitted to OSD in May 1982. In that POM, FY88 was the fifth year of the 5-year POM period, FY84 through FY88. By POM 88, FY88 had become the first year of the 5-year POM period. The instability of POM estimates, noted earlier (Figure 2-1), refers to instability in these successive POM estimates.

The next thing to notice in Figure 2-2 is that for the Air Staff to meet a May 1986 deadline for submitting POM 88 to OSD, AFLC must have its POM 88 estimates to the Air Staff by the previous fall. Given the quarterly schedule for D041/CSIS processing (discussed further below), this means that, for input to ALERT for POM 88 estimates, AFLC must rely on D041/CSIS data that were produced in June of 1985. POM forecasting horizons for AFLC, therefore, are more than 2 years for the first POM year, out to more than 6 years for the fifth POM year.

The dollar symbol in Figure 2-2 is a reminder that POM forecasts are projections of *funding* requirements. *Funding* enables the Air Force to obligate money to contractors and suppliers for spares; the spares themselves do not arrive until a procurement leadtime (PLT) later. Thus, in terms of *material* requirements, AFLC's POM forecasting horizons are from 4 to 8 years into the future, based on an average PLT for recoverable components that is now more than 2 years long.

We have just said that a POM forecasting model attempts to project the funding requirement for spares. What exactly do we mean by the "funding requirement"? Put another way, how exactly does the Air Force go about measuring the funding requirement? The answer is that the funding requirement for a given year is whatever the D041/CSIS/transition system says it is in the "last look" it takes at that year. To understand what this means, we must examine further the way the D041/CSIS/transition system operates.

The D041/CSIS system is run quarterly in June, September, December, and March. Full transition adjustments to the results are normally made after the March and September computations only. Transition adjustments involve a considerable amount of time-consuming, nonautomated interaction (e.g., meetings and management reviews) between the Air Logistics Centers and Headquarters AFLC. They are, therefore, normally done only for the quarterly computations used to sort budgets and POMs, that is, the March and September computations.

The June computation is the first in the four D041/CSIS computations each year. It projects item material requirements and asset positions for each quarter, out through a total of 25 quarters (6 $\frac{1}{4}$ years). The first quarter is the "current year" (CY). The next four quarters are the "apportionment year" (AY). The following four are the "budget year" (BY), and the four after that are the "extended year" (EY). The September computation drops the first quarter (the "current year" quarter in the June computation) and looks forward 24 quarters. The December and March computations do the same, looking forward 23 and 22 quarters, respectively.

To compute item *funding* requirements, the D041/CSIS system must back off a procurement leadtime from the time when item *material* requirements exist. Because there are items in the data base with a 3-year (12 quarter) procurement leadtime,⁶ aggregate funding requirements for the *whole* data base can be seen only 13 quarters ahead with a June data base (25 quarters minus 12 quarters). Thus, a June computation sees funding requirements in the CY (only one quarter long), the AY, the BY, and the EY. Similarly, a September computation sees funding requirements through 12 quarters – the AY, BY, and EY. (The CY exists for the June computation only.) December projects funding requirements for the last three quarters of the AY, and all of the BY and EY. March projects for the last half of the AY, and all of the BY and EY.

Because it is the first *scrubbed* D041/CSIS computation to see FY88, the September 1985 computation is called the "first look" at FY88. The "second look" at FY88 is the March 1986 computation done 6 months later. The last look at the FY88 requirement is the scrubbed computation in March 1988, 6 months into actual execution of FY88. It represents the sixth scrubbed D041/CSIS estimate of FY88

⁶In fact, there are items in the D041 data base with procurement leadtimes (PLT) greater than 3 years. For convenience in processing, however, D041 code imposes a cutoff of 3 years as a maximum allowable PLT.

requirements. It is based on the results of the first 6 months of actual execution in FY88, coupled with a requirements projection for the last 6 months.

To review: AFLC's spares forecasting problem for POMs is to provide the Air Staff each fall with projections of what the D041/CSIS/transition last-look estimates will be of funding requirements in each of the 5 POM years. For POM 88, therefore, ALERT must forecast what the last look will be for each of the years FY88, FY89, FY90, FY91, and FY92. To do this, AFLC must rely on an *unscrubbed* (i.e., non-transitioned) D041/CSIS computation from the prior June (e.g., June 1985 for POM 88). The June computation is the first D041/CSIS run to see the first POM year (which it sees as the extended year), and it is the *only* D041/CSIS run that produces results in time for AFLC and ALERT to meet Air Staff deadlines for initial POM estimates.

3. BUDGET AND EXECUTION: THE BEHAVIOR OF THE D041/CSIS/TRANSITION SYSTEM

INTRODUCTION

The previous chapter shows that POM forecasts for spares are attempts to project what another system, the D041/CSIS/transition system, will say the spares requirement is. The next chapter describes how ALERT attempts to do this — using data from various sources, including the D041/CSIS/transition system. Clearly, this system — the budgeting and execution system — is central to the requirements forecasting problem for spares in the Air Force. This chapter describes how the D041/CSIS/transition system behaves.

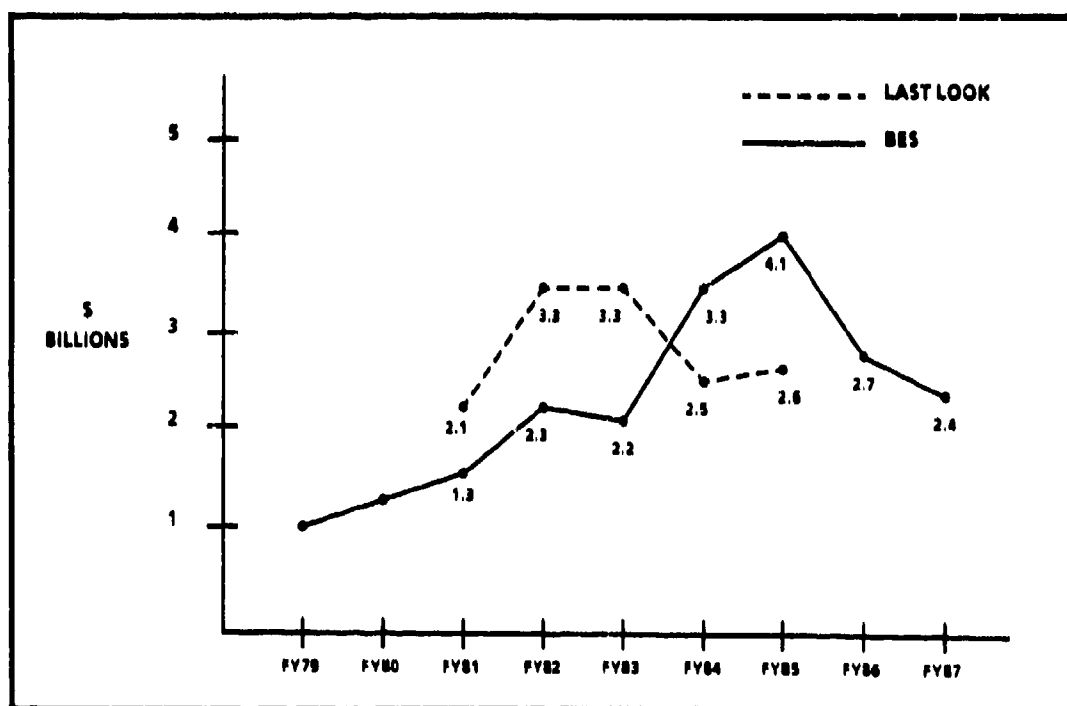
We have two main points to make. First we show that, from the time a budget estimate is made to the time a "last look" is taken at a given year's requirements, the D041/CSIS/transition system exhibits as much instability in its estimates of the requirement as POMs have been accused of doing. In the next chapter we will see how this volatility in the D041/CSIS/transition system taints ALERT projections, undermining both their stability and their potential for accuracy.

Second, we will show that changing D041/CSIS/transition estimates — more than changing POM estimates — are the prime cause of the credibility problem for spares in the Air Force. Thus, attempts to improve or develop new POM forecasting models, even if judged successful by some other criteria, still cannot and will not solve the fundamental problem. Even with a crystal ball for POMs, the Air Force will (and must, under established DoD supply policy) continue to make and execute spares budgets with a bottom-up, item-specific system, like the D041/CSIS/transition system. As long as that system continues to be volatile, the credibility problem will persist.

THE ROLLER COASTER FROM BUDGET TO LAST LOOK

Figure 3-1 compares Budget Estimate Submissions (BESs) for each of the years FY81 through FY85 with last looks for the same years. The figure shows that since the early 1980's, *budgets* for spares have been extremely poor indicators of what the Air Force eventually decides it wants to spend in actual execution. Figure 3-1 is the most important figure in this report. The volatility it depicts is fundamental to why POM forecasting is never likely to be successful. Even more important than the implication for POM forecasting, however, is the degree to which the *budgeting* system – the D041/CSIS/transition system – is not forecasting correctly. This failure of the budgeting system is the prime cause of the credibility problem for spares – more important than the failure of the POM forecasting system.

FIGURE 3-1. BES VERSUS LAST LOOK: FY81 - FY85



All the data in Figure 3-1 were obtained from official Air Force Budget Estimate Submissions to OSD. Because the message of the figure is central to the report and key to the arguments that follow, the source and meaning of the data in the figure should be well understood.

To explain the data in Figure 3-1, we focus on one year, FY85. Two data points appear over FY85. The point on the solid line, \$4.1 billion, represents the total POS budget request (POS total requirement) for FY85, as submitted by the Air Force to OSD in October 1983 in the FY85 BES.¹ That amount is based on D041/CSIS/transition processing of a March 1983 D041 data base by AFLC, followed by interaction and negotiations between AFLC and the Air Staff before final submission of the BES. In the language of the D041 calendar described in the previous chapter, D041/CSIS/transition processing of a March 1983 data base sees FY85 funding requirements as extended year (EY) requirements.

The point on the dotted line above FY85, \$2.6 billion, is the total POS requirement for FY85, as submitted by the Air Force to OSD in October 1985 in the FY87 BES² — a budget submission appearing 2 years *after* the FY85 BES. The FY87 BES still includes an estimate for FY85 because every BES includes a statement of the requirement, not only for the budget year, but also for the 2 years preceding the budget year. The difference for the preceding years is that their estimates are derived from the more recent D041 data base and D041/CSIS/transition-system processing underlying the new budget. The \$2.6 billion amount thus reflects the results of D041/CSIS/transition processing of a March 1985 data base by AFLC — the last look at FY85. In the language of the D041 calendar, D041/CSIS/

¹United States Air Force Budget for FY85 Budget Program 1500, Aircraft Replenishment Spares, 3010 Aircraft Appropriation (Summary of FY85 Budget Requirements), 1 October 1983, p. 3.

²United States Air Force, FY87 Budget Estimate Submission, Aircraft Replenishment Spares — BP-15, 3010 Aircraft Appropriation (Requirements Summary), 1 October 1985, pp. 1 — 4.

transition processing of a March 1985 data base sees FY85 funding requirements as apportionment year (AY) requirements.

In similar fashion, the two data points over each of the other fiscal years along the axis in Figure 3-1 were obtained from BESs that were separated in time by 2 years.

Figure 3-1 shows that for *every* fiscal year from FY81 to FY85 (the last fiscal year completed at the time of this report), there has been *at least* an \$800 million difference (in one direction or the other) between the budget estimate for the year and the last-look estimate for the same year.

Just as for POM estimates separated in time, we cannot expect budget estimates and last looks to be identical. Many things can and do change in the 2 years between the assembly of a budget and the taking of a last look. Further, if we take the traditional view that the D041/CSIS/transition process *defines* the requirement, we cannot really ask (as we did for POMs) whether the changes are large enough to explain such large fluctuations in the requirement. If the requirement is whatever the D041/CSIS/transition system says it is, the changes were, by definition, large enough.

The problem is that if a given year's spares requirement estimate really is subject to change by \$800 million or more between budget and execution, it becomes difficult to put much faith in annual budget submissions. So, the questions we have to ask are: What causes estimates of a given year's requirement to change, and is there anything the Air Force can do to monitor and (where possible and appropriate) control the changes to bring budgets and last looks closer together?

WHY DO D041/CSIS/TRANSITION ESTIMATES CHANGE ?

Changes in the planned force size, in schedules for modernization and modification programs, and in the planned flying-hour program explain in part why D041/CSIS/transition estimates of a given year's requirement will change from year to

year. As we have seen, however, these changes are generally not enough to explain fluctuations as large as those recorded in Figure 3-1. If these were the only factors causing estimates to change, stabilizing the spares requirement would mean basing some program decisions on spares effects. Although this would be putting the cart before the horse for many programs, it might make sense in some cases. Certainly, taking spares effects into account when making program decisions (e.g., flying-hour program decisions) is a good idea. Air Force planning should be flexible -- but mechanisms for senior management review must exist to ensure that changes that will significantly modify the budget are necessary and important enough to justify those modifications.

What about funding decisions for prior years? What effect do they have on successive estimates of a year's requirements? Unlike POMs, budget requests may include unfunded carry-over requirements arising as a result of prior-year funding decisions by OSD and Congress. Unfunded carry-over requirements are in addition to "stand-alone" requirements computed for a given year. Unfunded carry-over supposedly represents real requirements that continue to exist and continue to require funding. This means that funding decisions for prior years, made by organizations outside the Air Force, can influence the size of the total budget request for a given year. Even within the Air Force, if the Air Force Comptroller or other elements of the Air Staff elect not to go forward with what AFLC has determined (using the D041/CSIS/transition system) to be the budget requirement, next year's computed budget from AFLC, which includes transition adjustments made by AFLC management, may include carry-over.

The budget requests in Figure 3-1 include both kinds of requirements -- computed, stand-alone requirements and unfunded carry-over requirements -- for each year. The budget figure of \$4.1 billion from the FY85 BES, for example, is the sum of a computed requirement of \$3.3 billion for FY85 and a prior-year unfunded

carry-over requirement of \$0.8 billion from FY84 into FY85. We have compared the \$4.1 billion figure, rather than \$3.3 billion, with the last look of \$2.6 billion for FY85.

There are two reasons why it is correct to compare the \$4.1 billion with the \$2.6 billion, as we have done. First, the last look of \$2.6 billion includes any requirements that really did carry over from FY84 into FY85. Thus, since the last look includes both computed and carry-over requirements, it is appropriate to compare it with the total budget request -- not just the stand-alone portion. Second, the \$4.1 billion request in the FY85 BES *already includes and takes into account* funding decisions for FY84 and FY83. In October 1983, at the time of the FY85 BES, FY83 is ending and FY84 is starting, and funding decisions for both years have already been made. These funding decisions have been taken into account in the BES's statement of the FY85 requirement.

Funding decisions that *can* help explain a difference between a BES and a last look are funding decisions made *after* the BES is submitted. For the FY85 BES, for example, a decision after October 1983 to change the funding in FY84 would help explain why the last look for FY85 could turn out to be different from the BES for FY85 -- because the BES "didn't know" the correct funding figure for FY84 and got the unfunded carry-over portion of the FY85 requirement wrong. Because such late decisions occur, it is true that funding decisions can cause BESs and last looks to differ. However, late funding decisions will normally not differ radically from the funding decisions already recorded in the BES. This means that funding decisions, like program changes, are usually not enough by themselves to explain large fluctuations, like those shown in Figure 3-1. (The turmoil in funding decisions for FY86, related to Congressional action on the Gramm-Rudman-Hollings legislation, serves as a recent exception to this rule and will certainly contribute to differences between

the FY87 budget, submitted in the fall of 1985, and the last look at FY87, to be taken in the spring of 1987.)

There are other mechanisms in the D041/CSIS/transition process that cause estimates to change. These mechanisms are different in the three phases of the process. D041 calculations are subject to "churn" in the item data base. Stratification treats a year differently when it is an outyear (BY or EY) than when it is an apportionment year. And transition adjustments are not always consistent from one year to the next. We shall look at each of these in turn.

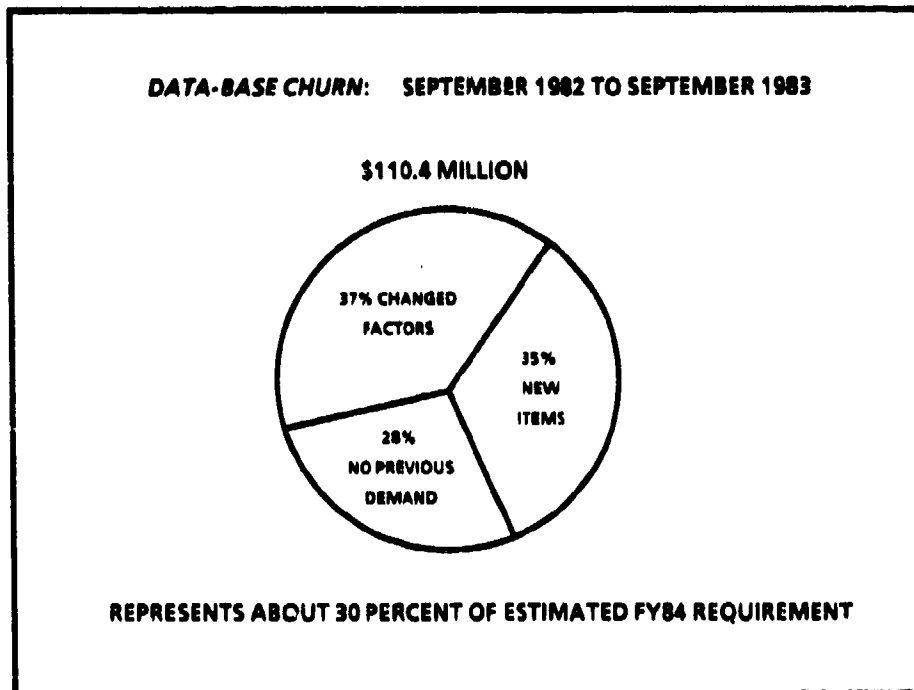
Figure 3-2 presents some preliminary results concerning churn in the D041 data base.³ Churn refers to the tendency of item characteristics to change over time. The Air Force recognizes that its inventory processes are stochastic – or variable – processes, which can only be described in terms of averages and other statistical parameters. In these terms, the idea of churn is that many of the parameters the Air Force uses to characterize its inventory processes (e.g., demand rates, resupply times, prices) are not stable over time. In other words, the world is not "steady state." Figure 3-2 illustrates the potential effect of churn on successive estimates of a given year's requirement.

Figure 3-2 shows that, in successive calculations of a FY84 spares requirement for F-16As and F-16Bs from a September 1982 data base and a September 1983 data base, approximately \$110.4 million in new requirements appear in the second calculation, as a result of changes in various item characteristics from one data base to the next. (Every D041 calculation makes a "steady-state" assumption for the data it uses.) Both calculations were done to achieve an 80 percent aircraft availability rate. The second calculation assumed all the requirements from the first calculation

³For background on churn and further details on the data in Figure 3-2, see Randall M. King and Virginia A. Mattern, *The Effects of Data Base Dynamics in Estimating Spares Costs: An Analysis of the F-16*, Working Note AF501-2 (Bethesda, Maryland: Logistics Management Institute), December 1985.

were bought and in the inventory. It is in this sense that the \$110.4 million in requirements are new — they reflect the failure of many item factors to stay the same from one September data base to the next.

FIGURE 3-2. D041 DYNAMICS
(F-16A/F-16B Example)



In the breakdown of the \$110.4 million, roughly a third is due to changes in item parameters such as failure rates per flying hour, repair times, and not-reparable-this-station (NRTS) rates. Another third is a result of items that presented nonzero demand rates for the first time. The last third is attributable to new items — items with stock numbers that were simply not present in the earlier data base. Very little of the \$110.4 million is a result of changes in the planned operating program. The underlying flying-hour programs and fleet sizes were essentially the same for both calculations. Also, requirements related to replacement of condemnations and additives are not included in the \$110.4 million.

As an indicator of the relative size of churn effects, the \$110.4 million represents approximately 30 percent of an availability-based estimate of \$345 million as the total FY84 spares requirement (to achieve an 80-percent aircraft availability rate) for F-16As and F-16Bs.

These results concerning churn are preliminary. They do not take real-world asset levels into account, nor do they reflect the fact that churn effects will be negative for some items, causing a reduction in the overall effect. Churn in item requirements arising as a result of price changes (as opposed to changes in demand rates and resupply times) was not part of this initial analysis. Because only two data bases were examined, and then only for components on the F-16A and F-16B, the results cannot be generalized to the whole D041 data base. The results also do not take into account that part of the *purpose* of transition adjustments (e.g., "scrubs") at the *end* of the D041/CSIS/transition process is to account for churn. Even with these qualifications, however, there is no question that churn in the spares data base is another reason why budgets and last looks will never agree precisely.

Another reason budgets and last looks tend to differ is a result of the way in which assets are treated in the stratification of outyear requirements. *Requirements* in earlier years are treated as *available assets* in the computation of later-year requirements. As a result, once inventory levels are built in the early years, computed requirements for the outyears tend to look like nothing more than the replacement of condemnations. As a result, because budgets see a year as the extended year, and last looks see it as the apportionment year, budgets tend to understate in relation to last looks, other things being equal. Again, transition adjustments are supposed to compensate for this bias, but they are not always successful — particularly when the overall Air Force program is in flux.

Transition is the third phase of the D041/CSIS/transition process. In transition, the results of item-level D041/CSIS computations are scrubbed, errors are

corrected, additive requirements not in the item data base are inserted, and other management adjustments are made. Transition is so named because it is the process that transforms a stratified requirements computation into an official budget. Lack of consistency in transition adjustments is a third reason why budgets and last looks disagree. Table 3-1 illustrates an example of this lack of consistency. It compares transition adjustments made at Air Logistics Centers for a September 1984 D041/CSIS computation with those for a March 1985 computation 6 months later. In each case, the adjustments were made to produce an estimate of the FY87 requirement. (FY87 was the extended year for both computations.)

TABLE 3-1. INCONSISTENT TRANSITION ADJUSTMENTS
Comparison of Transition Adjustments for FY87
September 1984 Computation versus March 1985 Computation
(\$000)

TRANSITION ADJUSTMENTS	FY87 (EXTENDED YEAR)	
	September 1984	March 1985
Computed CSIS deficit	1,150,610	1,576,998
Error adjustments	- 106,923	- 121,213
Scrub adjustments	157,780	708,911
Additive requirements	205,152	369,046
Other adjustments	102,037	16,539
Total peacetime requirement	1,508,656	2,550,281

Table 3-1 illustrates how *management* decisions in transition can contribute to differing estimates of the same year's requirement. The bottom line in the table shows that even though there is only a 6-month difference in age between the September 1984 D041 data base and the March 1985 data base, the total estimated requirement for FY87 increased by more than \$1 billion. The "computed CSIS

deficit" line at the top of the table shows that about \$426 million of this increase is due to changes *within* the item data base and in the resulting computed requirement. Program changes and churn contribute to this part of the difference. The remainder of the difference, more than \$550 million, is due to changes in management decisions made *about* the computed requirement *outside* the data base. Table 3-1 shows the three categories of transition adjustments that account for most of the dollars in transition: error adjustments, scrub adjustments, and additive requirements. Other, smaller categories of transition adjustments have been combined in the "other adjustments" line.

The "error adjustments" line shows that the September computation overstated the FY87 requirement by \$103.9 million because of erroneous item-level data in the data base. Errors in the March data base led to a \$121.2 million overstatement. Because 6 months separate the data bases, it is reasonable to assume that most of the errors in the September data base were corrected in the one for March. This means that most of the \$121.2 million in errors in March consisted of new (or newly discovered) errors. Errors and error adjustments are a reflection of how human error in entering or adjusting data can contribute to differences in estimates.

The "scrub adjustments" line shows that in the 6 months between September 1984 and March 1985, the Air Logistics Centers changed their statement of FY87 requirements by more than \$550 million. That is the difference between the scrub adjustments for September and March. In this case, a large portion of the difference was caused by a large increase in additive requirements for the B-1 bomber, requested by the System Program Manager (SPM). For the September 1984 data base, the SPM specified additive scrub adjustments for the B-1 of +\$357.8 million for FY86 and +\$7.6 million for FY87. For the March 1985 computation, these estimates had increased to +\$921.9 million and +\$562.3 million. In other words, between POM 87 (supported by the September 1984 computation) and the budget for

FY87 (supported by the March 1985 computation), the SPM added more than \$800 million in B-1 spares requirements to *both* the FY86 requirement and the FY87 requirement. This is not to say these new requirements were not valid. It does show, however, that Air Force efforts to bring budgets and last looks closer together will have to involve not only better control of the spares data base but also better control and discipline in the management decision process that takes place outside the data base.

The "additive requirements" line shows that estimated additive requirements (net) increased by more than \$160 million. Additive requirements are for stocks to support special, nonrecurring programs, such as modification programs or spares buy-out programs. In transition, the adjustment line for additive requirements is for additives *outside* the data base. (Additive requirements *within* the data base are adjusted with scrub adjustments.) Thus, the more than \$160 million increase in the additive adjustment means that, between September and March, decisions were made to do special programs in FY87 that were not part of the plan in September.

Finally, not all transition inconsistencies originate within the logistics community. A form of transition occurs between the submission of an AFLC budget estimate to the Air Staff and the Air Staff's final submission to OSD. Air Staff adjustments to the requirement are another reason why requirements estimates change. Although Air Staff adjustments may be necessary given the nature of the resource allocation process in the Pentagon, they must, nevertheless, be recognized as contributors to the problem of unstable estimates.

Many specific examples of how *management* decisions, made *after* budgets have been set, can cause a given year's requirement to change are documented in the CORONA REQUIRE study (cited earlier), which was conducted within the Air Force in 1983. The purpose was to explain why and how the last look at the FY82 spares requirement was close to \$1 billion *greater* than the budget for FY82, which at

\$2.448 billion (POS) was the largest spares budget the Air Force had ever submitted.

The following is taken from the Executive Summary of the CORONA REQUIRE report:

Forty percent of the final FY82 requirement was generated by additives or corrections resulting from off-line management decisions. The computer system (D041), commonly touted as the sole cause of the problem, was not the lone culprit. Managers throughout the system are allowed to enter unprogrammed requirements into the data base at any time. As a result, requirements grow, independent of funding considerations.

The fact that budgets and last looks have continued to differ since the time of CORONA REQUIRE is evidence that many of the problems identified are yet to be solved.

Without arguing with the main thrust of the CORONA REQUIRE conclusion, it is important to note that management decisions do not always cause the requirement to *grow* between budget and last look, as CORONA REQUIRE implied. At the time of CORONA REQUIRE, growth was indeed the problem. For the years FY84 and FY85, however, the opposite was the case. As shown in Figure 3-1, the last looks for FY84 and FY85 were well *under* the original budget estimates. Some of this change was due to changes in the data base, and some to management decisions and estimates that the requirement would be smaller. In this period, for example, Air Force management was arguing that cost savings resulting from increases in competition were bringing spares requirements down.⁴

The fact that last looks were *smaller* than the budget estimates for FY84 and FY85 made no difference in the credibility problem. In fact, Congress questioned the validity of requirements estimates for FY86 and FY87 partly on the grounds that the

⁴An alternative approach would have been to say that cost savings from competition initiatives were allowing the Air Force to buy better supply support and more readiness from the approved budget. Another possible approach would have been some compromise between the two: *some* reduction in requirements, along with *some* improvement in support.

Air Force was not able to spend all it had asked for and gotten in its FY84 and FY85 spares budgets.

Finally, changing item prices—and the many factors that can cause prices to change—are another potentially significant reason why requirements estimates may change from budget to last look. Competition advocacy and breakout programs, changes in contracting and ordering procedures, and re-pricing agreements all will cause estimates to change—sometimes significantly.

Taken together, the many reasons and pressures discussed in this chapter explain how budget and last-look estimates can differ by amounts as large as those in Figure 3-1. The next question is whether forecasting tools, like ALERT, can somehow rise above the behavior of the budgeting and execution system and make accurate and stable forecasts of spares requirements for POMs. If not—and the next chapter argues that ALERT cannot—the Air Force has no alternative but to instill greater discipline, control, and stability in the programming, budgeting and execution process, if the credibility problem for spares requirements is to be solved.

4. HOW ALERT WORKS AND WHY IT WON'T SOLVE THE CREDIBILITY PROBLEM

FOUR CRITERIA FOR EVALUATING A POM FORECASTING MODEL

The Air Logistics Early Requirements Technique (ALERT) forecasts aircraft POS spares requirements for POMs. It does so by attempting to predict what the "last-look" estimate with the D041/CSIS/transition system will be for each of the 5 POM years. For example, ALERT's POM 88 forecasts are projections of what the last looks will be for the years FY88, FY89, FY90, FY91, and FY92.

ALERT forecasts are produced with equations derived through regression analysis of historical spares requirements. Separate linear regressions are done for each of 17 Air Force "systems" that generate aircraft spares requirements, including: 14 different aircraft types (by M/D - Mission/Design), the F-100 engine, common components, and "other systems." Historical requirements data, budget projections, age-of-the-fleet and value-of-the-fleet data, and certain other technical data serve as data points and inputs to the regressions. Every year, with the addition of another year's worth of history, ALERT regressions are redone and new equations are developed for the POM forecasts to be made that year.

ALERT's success or failure as a forecasting model will be determined by four things: its conceptual validity, its degree of precision, its ability to deliver stable estimates, and its predictive accuracy. Conceptual validity and degree of precision are *internal* characteristics, determined by the way the model works and the input data it has to work with. Stability and accuracy are *external* characteristics, determined by the behavior of the model's forecasts over time and the level of accuracy they achieve. Of the four characteristics, stability and accuracy of forecasts are the most important. If a model cannot deliver stable and accurate forecasts, it will not solve the credibility problem for spares.

ALERT's characteristics and performance in each of the four areas are evaluated in this chapter. As we shall see, ALERT has problems in every area. The most serious are in the stability and accuracy of its forecasts. All of the problems discussed are due, either directly or indirectly, to the volatility of D041/CSIS estimates, which play a central role in the ALERT methodology. The conclusion is that ALERT cannot and will not solve the credibility problem for spares. We begin with a review of how the model works.

HOW ALERT WORKS

ALERT was developed by the Materiel Management Directorate at AFLC (AFLC/MMMA) in the fall of 1983. The ALERT regression approach extends an approach employed in another POM forecasting model for spares, the POS Spares Estimating Model (POSSEM), which was developed by the Air Staff (HQ USAF/AC). ALERT was used officially for the first time for POM 87. POSSEM was used for POM 86 and POM 85. Prior POMs were done with a cost-per-flying-hour (CPFH) method. To obtain POM spares estimates, the CPFH method applies a CPFH factor, derived from the budget-year requirement, to the planned flying-hour program for the POM years. The CPFH method is flawed by its failure to recognize spares requirements as *net* requirements. POSSEM and ALERT were intended to replace the CPFH method and serve as improved POM forecasting techniques.

In describing the ALERT methodology, we shall use POM 88 as an example. The description may be applied to any other POM cycle by adding (or subtracting) the same number of years, as appropriate, to all numerical expressions for years that appear in the description.

AFLC must submit POM 88 estimates to the Air Staff in the fall of 1985, 2 years before the first POM year, FY88. The unscrubbed estimates from the June 1985 D041/CSIS computation are the most current D041/CSIS estimates available in time to meet the fall deadline. The June 1985 estimates are for the current

year (CY — the last quarter of FY85), the apportionment year (AY — FY86), the budget year (BY — FY87), and the extended year (EY — FY88).

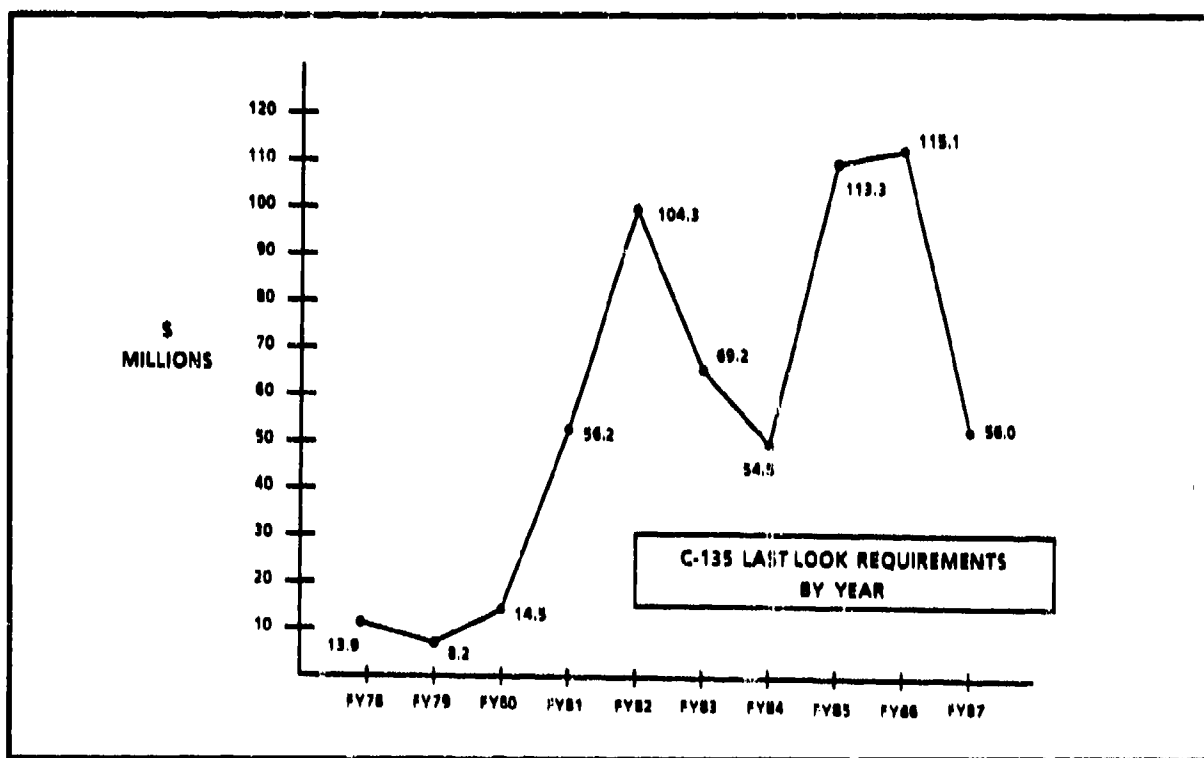
The variable to be predicted in an ALERT forecast is a D041/CSIS/transition last look. For POM 88, ALERT attempts to predict the last look for each of the years FY88 through FY92. The historical data underlying the forecast are actual last-look values for FY78 through FY85. Because it is the fall of 1985, FY85 is the last year for which an actual last look is available (from the March 1985 D041/CSIS/transition computation). There is no history yet for the 2 remaining years, FY86 and FY87, that lie between FY85 and the first POM year, FY88. Instead, ALERT uses *scrubbed estimates*, again from the March 1985 computation, as the "history" for those 2 years.

This last point is important. It identifies the first instance in which ALERT relies upon an early look with the D041/CSIS/transition system to say what a last look will be. A last look is the last in the sequence of six D041/CSIS/transition runs that see a given year.¹ The March 1985 D041/CSIS/transition computation represents only the fourth look at FY86 and only the second look at FY87. In each case, however, ALERT treats these estimates as if they were last looks. Of course, ALERT does not have much choice. Something must be used as history for FY86 and FY87 — trying to forecast for POM 88 on the basis of history that extends through FY85 only is not very palatable — and it is hard to imagine other variables that could be counted on to do any better. Nevertheless, because of volatility in the D041/CSIS/transition system, we will see that use of early looks as history seriously diminishes ALERT's ability to make accurate forecasts.

¹Beginning with a June computation, the D041/CSIS system (which is run quarterly) will compute a given year's requirement a total of 13 times. Of those 13 computations, only 6 undergo transition (scrubs). These 6 D041/CSIS runs with full transition are the 6 "looks" at a given year.

Figure 4-1 shows the historical values of the dependent variable (last looks) for one weapon system, the C-135 aircraft, that went into the ALERT regression analysis for POM 88. For its POM 88 forecasts, ALERT used historical data for the years FY78 through FY85. As explained above, the values shown for FY86 and FY87 are estimates, not true last looks.

FIGURE 4-1. ALERT INPUT DATA



ALERT is a stepwise, multilinear regression model. As a regression model, it approaches the problem of projecting the next five values (for the years FY88 through FY92) for a system like the C-135 by asking: Is there a set of observable variables that "explains" most of the variation in the system's requirements?

If we can find such variables, as well as a functional relationship between them and the last-look variable we are trying to project, we can use that relationship to

forecast future last looks. Regression is a standard statistical method for finding such relationships.²

The independent predictor variables used in ALERT regressions are: the dollar value of the fleet by system (for the 17 systems addressed by ALERT); the reciprocal of the age of the fleet by system; a dummy variable to control for what AFLC deems are nonrecurring phenomena in the historical data; and the computed (but unscrubbed) CSIS deficit for the extended year from the June D041/CSIS computation preceding ALERT projections each fall. The value of the computed D041/CSIS deficit is modified by addition of the value of on-order assets at the beginning of the extended year as calculated in the June computation.³ ALERT also uses calendar year occasionally as an independent predictor variable.

With the exception of the dummy variable, which serves as a mechanism for adjusting ALERT forecasts based on AFLC management inputs, each of ALERT's independent variables can — when necessary — be observed, measured, or predicted. What the age and value of the fleet will be at the time of a last look can be predicted

²ALERT is *not* a time-series regression. In a time-series analysis, the chronological order in which historical last looks present themselves (e.g., the order in Figure 4-1) would influence the projected values of future last looks. This is not the case for ALERT projections. In the case of the C-135, for example, changing the position of the last looks over the horizontal axis (the time axis) in Figure 4-1 would not change the forecasting equations and final projections that ALERT derives from those data. Readers are cautioned, therefore, to be careful when they think of ALERT as "fitting a straight line" to the data shown in Figure 4-1. ALERT finds a linear relationship between those data and other variables, but it does not attempt to say that requirements are a linear function of *time*. (An exception is ALERT's occasional use of the calendar year as an independent, predictor variable — discussed later.)

³The reason given in ALERT documentation for adding the value of on-order assets to the computed deficit is that:

Inspection of past CSIS products indicated the "total buy" (the sum of on-order plus the deficit) to be more closely aligned with eventual (last look) requirements. The computed deficit appeared to be understated relative to the eventual budget (the last look) throughout the history of the data. Reasons were not analyzed.

We shall return to this point in the discussion of ALERT's conceptual validity. For now, one of the reasons early CSIS deficits are consistently understated relative to last looks is that stratification converts near-year requirements into outyear assets. This makes outyear requirements look like nothing more than the replacement of condemnations. As we have seen in Chapter 3, however, reparables requirements involve substantially more than replacement of condemnations each year.

with reasonable certainty from force structure plans. The value of the D041/CSIS variable is directly observable from the June computation that precedes the ALERT forecast.

Still using POM 88 as an example, ALERT's stepwise regression proceeds as follows: For the first POM year, FY88, ALERT regresses historical values of the June D041/CSIS variable against actual, historical last-look values for FY78 through FY85 (and the estimated history for FY86 and FY87). The June D041/CSIS variable is *always* a predictor variable for the first POM year. For the regression, historical values of the independent D041/CSIS variable are appropriately time-lagged against historical last looks. For example, the value of the June 1981 D041/CSIS computation is associated with the last look for FY84. The regression is stepwise in that it may choose one additional variable from the remaining independent variables (age, value, or year) as an additional predictor, if the addition of that variable will "enhance" ALERT's predictive ability. The degree of "enhancement" is judged by the coefficient of determination (r^2) obtained in the regression.

For the POM outyears, the second through fifth POM years, there is no D041/CSIS variable available for use as an independent variable in a regression. Therefore, ALERT regresses against value of the fleet, enhanced by stepwise selection of one more of the remaining variables — either age of the fleet or calendar year.

D041/CSIS products still influence the outyear projections, however. Just as ALERT uses D041/CSIS early-look estimates as history for the 2 years preceding the first POM year, ALERT treats its own projection for the first POM year as 1 more year of "history" for the outyear regressions. Thus, D041/CSIS system estimates of near-year requirements indirectly influence outyear projections.

The dummy independent variable in ALERT assumes the value zero or one for the regression. The value of one is used for any historical years (or future years) that AFLC management believes had (or will have) abnormally high requirements.

The ALERT regressions result in equations that express the dependent variable (last look) as a linear combination of the independent variables. These equations are the ones used to make POM forecasts. The first two equations in Figure 4-2 are generic examples. The first equation, for the first POM year, always involves at least the June D041/CSIS variable and perhaps one of the enhancer variables (ENH), a constant term, and the dummy variable called PEAK, to control for abnormal peaks in the requirement. The second equation in Figure 4-2 shows the form of the forecasting equations for the POM outyears. The coefficients B_1 and C_1 are derived in the ALERT regressions.

FIGURE 4-2. ALERT FORECASTING EQUATIONS

$$\begin{aligned}
 \text{1ST POM YEAR} &= B_0 + B_1(\text{D041/CSIS}) + B_2(\text{ENH}) + B_3(\text{PEAK}) \\
 \text{2ND - 5TH POM YEARS} &= C_0 + C_1(\text{VALUE}) + C_2(\text{ENH}) + C_3(\text{PEAK}) \\
 &\text{E.G.,} \\
 \text{C-135 FY88 REQUIREMENT} &= 383.7 + (-170)(\text{D041}) + (-6231)(1/\text{AGE}) \\
 \$63.5 \text{ MILLION} &= 383.7 + (-170)(0.564) + (-6231)(0.036)
 \end{aligned}$$

ALERT produces such equations for all of its 17 systems. The equation at the bottom of Figure 4-2 is the equation ALERT produced to forecast FY88 requirements for the C-135 for POM 88. The computed deficit in FY88 for the C-135 (from the June 1985 D041/CSIS computation, with the value of on-order assets added) is \$0.564 million. The average age of the C-135 fleet in FY88 will be 27.8 years, with a

reciprocal value of 0.036. The predicted value of the last look for C-135 requirements in FY88 is \$63.5 million.⁴

WHY ALERT WON'T SOLVE THE CREDIBILITY PROBLEM

ALERT will not solve the credibility problem for spares because it has conceptual problems, precision problems, accuracy problems, and stability problems.

Conceptual Problems

Conceptually, ALERT has many appealing features. Regression is a standard forecasting technique, and ALERT is innovative in its use of early look D041/CSIS/transition estimates as inputs for projections of what last looks will be.⁵ Value and age of the fleet make sense (and have been used elsewhere in DoD) as predictors of spares requirements. And, from a practical perspective, the use of a dummy variable to allow input from AFLC management is a good idea. AFLC is the Air Force organization responsible for spares management and the most

⁴The equations for the C-135 shown in Figure 4-2 are *direct* ALERT output produced in September of 1985. In general, the technical evaluation of ALERT in this chapter is based on direct model outputs, which may not reflect final management adjustments. (Before ALERT forecasts become official, they are subject to management adjustment, both by AFLC and by the Air Staff.) As a result, the final C-135 FY88 projection delivered to the Air Staff in the fall of 1985 may differ from the projection in Figure 4-2.

⁵In developing a regression model, it is good practice to choose independent variables that can be related in some sensible way to the dependent variables. It is very reasonable *in concept*, therefore, to choose *early* D041/CSIS/transition estimates as the key indicator of what *later* D041/CSIS/transition last looks will be. Recognizing that early looks and last looks do differ, it is also appealing that ALERT uses the early estimates as inputs to a regression analysis, rather than attempting to use them directly. This indirect use of early D041/CSIS estimates was deliberate in the course of ALERT's development. The following statement from ALERT documentation describes a key assumption underlying the ALERT approach:

The summary of the D041 item-by-item computation of the buy requirement provides valuable information relating to the final requirement at the M/D level, and represents the most likely predictor for eventual requirements. Due to the dynamics over time, this computation is subject to change. One of the objectives of the ALERT model is to capture the direction and strength of this change.

We cannot argue with this *concept*. But the central finding of this study (reflected in the previous chapter and in later analysis of ALERT's stability and accuracy) is that there is *so much* volatility in the D041/CSIS/transition system that, even though it may be the best predictor conceptually, it proves a *very bad* predictor in practice.

knowledgeable about spares requirements. It makes sense to provide a mechanism for incorporating AFLC judgment into the spares forecasting model used for POMs.

But ALERT does have some conceptual problems that reduce its credibility. For example, the fact that new equations are developed and used to forecast each year automatically undermines the credibility of previous forecasts made earlier. This is particularly a problem when a given year becomes a first POM year, after having been a POM outyear for 4 years. For the first POM year, the introduction of the D041/CSIS variable into the predicting equation makes it highly unlikely that the new prediction will be consistent with earlier predictions. (We shall see evidence of this later in the discussion of ALERT's stability problems.)

Another conceptual problem is in ALERT's occasional use of the calendar year as a predictor variable. Given the simple linear form of ALERT's forecasting equations, use of the calendar year as a predictor variable implies that the spares requirement for a system will change by the same amount each year. The fact that this may have been the case over some sequence of years in the past is no reason to believe it will continue into the future. Spares requirements are not necessarily time-independent in all respects, but a simple linear relationship is unlikely.

Another of ALERT's conceptual problems is the combination of assets and requirements in the D041/CSIS predictor variable. Assets and requirements affect the requirement in opposite ways. Combining assets and requirements, therefore, yields a hybrid variable that has no intuitive content or sensible relationship to the predicted variable. Without such a relationship, regressions tend to be artificial and unconvincing.

ALERT's most serious conceptual problem, in fact, is that the predicting equations it generates cannot be understood in terms of any reasonable physical relationship. As a result, there is no conceptual reason to believe they are good predictors. To illustrate, the equations below are the FY88 forecasting equations

ALERT produced for the F-16 and F-15 for POM 88. For both systems, the D041/CSIS variable is the only predictor variable:

$$\text{F-16 FY88 requirements} = 73.3 + (+66.9) (\text{D041/CSIS})$$

$$\text{F-15 FY88 requirements} = 139.0 + (-42.0) (\text{D041/CSIS})$$

The equations are similar except that the coefficients for the D041/CSIS variables have opposite signs. In the case of the F-16, the positive sign implies that the greater an earlier estimate of FY88 requirements, the greater those requirements will eventually be. This would seem to make sense. But then for the F-15, the opposite is true: The greater the earlier estimates, the *smaller* the eventual FY88 requirements. The use of the D041/CSIS variable as a predictor of spares requirements only makes sense if it works the same way for all systems. In general, the fact that signs vary is an indicator *within ALERT itself*, that early D041/CSIS estimates are highly unreliable as predictors of eventual requirements.

Precision Problems

A model's precision is different from its accuracy, in the same way that the scatter pattern of a shotgun is different from the marksmanship of the shooter. Here, we look at ALERT's internal precision – its scatter pattern.

Regression relationships are relationships between *mean* or *average* values of the independent and dependent variables. They can be counted on to be exactly accurate for only the sample means of the observed values of those variables. Away from those means, regression predictions are nothing more than estimates of the mean value of a random variable. When ALERT makes a prediction, therefore, it is estimating the mean value of a variable that can take on many different values. ALERT's accuracy is a question of whether it is a good predictor of the mean – is the shooter a good marksman? Its precision is a measure of the inexactness of the estimate – how big is the scatter pattern? This inexactness is a function of sampling

error in the estimate of the mean and of variance in the dependent (predicted) variable that is not accounted for by the regression relation. The amount of inexactness in a prediction can be quantified in terms of prediction intervals. Prediction intervals are interval estimates of future values of the dependent variable, centered on point estimates of the mean. Associated with every prediction interval is a probability that the projected interval has "captured" the desired value of the dependent variable. This probability and the width of the interval provide a measure of the inexactness of the prediction. Figure 4-3 illustrates a prediction interval around ALERT's point estimate of \$55.2 million as the C-5's FY88 requirement.

FIGURE 4-3. ALERT'S STATISTICAL ERROR AT THE SYSTEM LEVEL

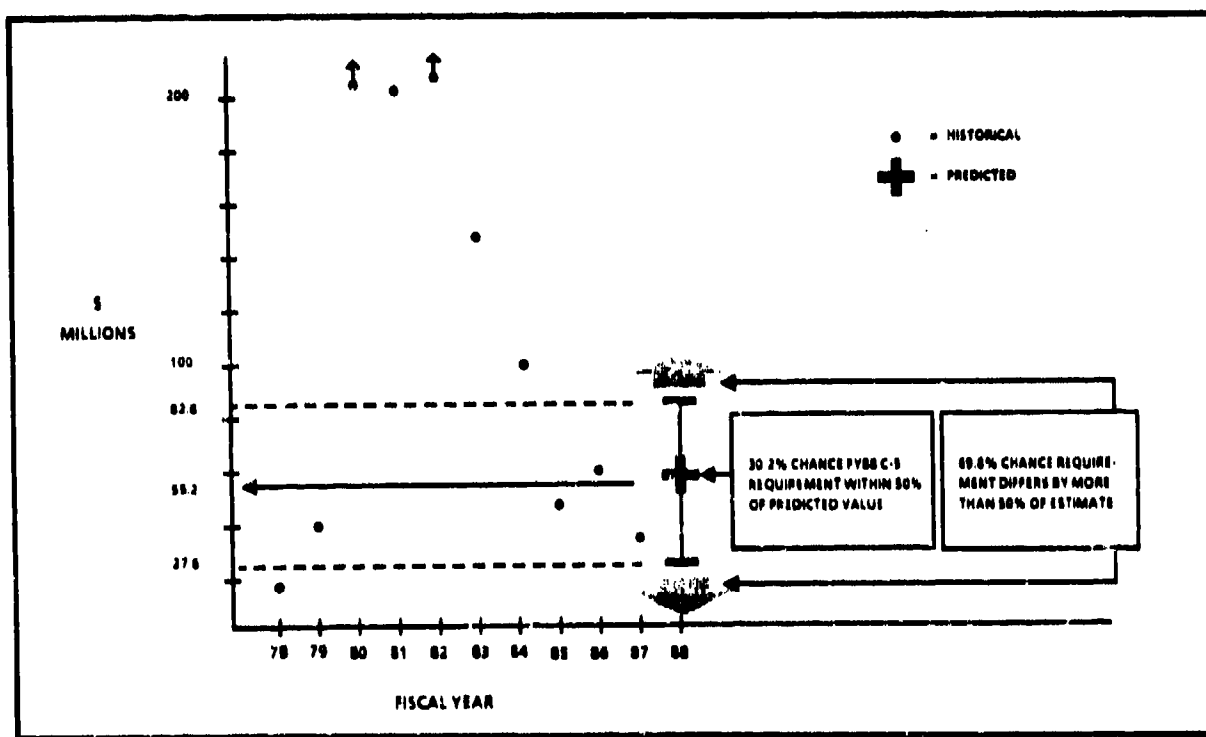


Figure 4-3 expresses the ALERT projection for the C-5 in the following way: Given the historical values of last looks for the C-5 from FY78 through FY87

(plotted in the figure), and the way the ALERT works, there is a 30.2 percent chance that the interval defined by \$55.2 million plus or minus 50 percent of itself (i.e., the interval from \$27.6 million to \$82.8 million) includes the C-5's FY88 requirement. Put another way, we can say with only 30.2 percent confidence that the C-5's FY88 requirement will be between \$27.6 million and \$82.8 million. In other words, the point estimate of \$55.2 million is not very precise.

In fact, ALERT developers have acknowledged that ALERT does not generate reliable estimates at the weapon-system level. The data in Table 4-1 are taken from an AFLC comparison of ALERT with the POSSEM model. For each weapon system, AFLC tested ALERT's ability to interpolate historical requirements levels, given information about true last looks on both sides of the interpolated year. This was done for each year from FY78 through FY86. For each year and each weapon system, AFLC measured the mean absolute percentage error (MAPE) between the ALERT interpolation and the actual last look for the year. These MAPEs were then weighted by the size of the requirement in each year and averaged, to yield a single weighted, weapon-system MAPE for the period FY78 through FY86. As the table shows, ALERT's percentage error ranged from a low of 23 percent to a high of 112 percent, with an (unweighted) overall average error of 63 percent per system.

Although precision at the system level is desirable, it is not crucial for POMs. For POMs, the *aggregate* estimate is of prime importance. What is ALERT's precision at the aggregate level?

Summing across all 17 of its systems, ALERT's precision is better in the aggregate than it is at the system level. For example, an interval estimate of \$2.15 billion, plus or minus \$430 million (20 percent), has an 87-percent chance of "capturing" the aggregate FY88 requirement. *This assumes that the point estimate of \$2.15 billion is an accurate estimate of the mean.* A tighter prediction interval of

**TABLE 4-1. ALERT IMPRECISION AT THE
WEAPON-SYSTEM LEVEL: FY78 - FY86**

M/D	PERCENT ERROR	M/D	PERCENT ERROR
A-7	112	F-4	23
A-10	85	F-5	109
B-52	85	F-15	50
C-130	64	F-16	35
C-135	66	F-111	47
C-141	78	F-100	29
C-5	63	Other	24
E-3	47	T-38	91

Note: Unweighted average: 63 percent

\$2.15 billion plus or minus \$215 million (10 percent) has a 55-percent chance of covering the requirement. How these aggregate prediction intervals were computed is explained in the Appendix.

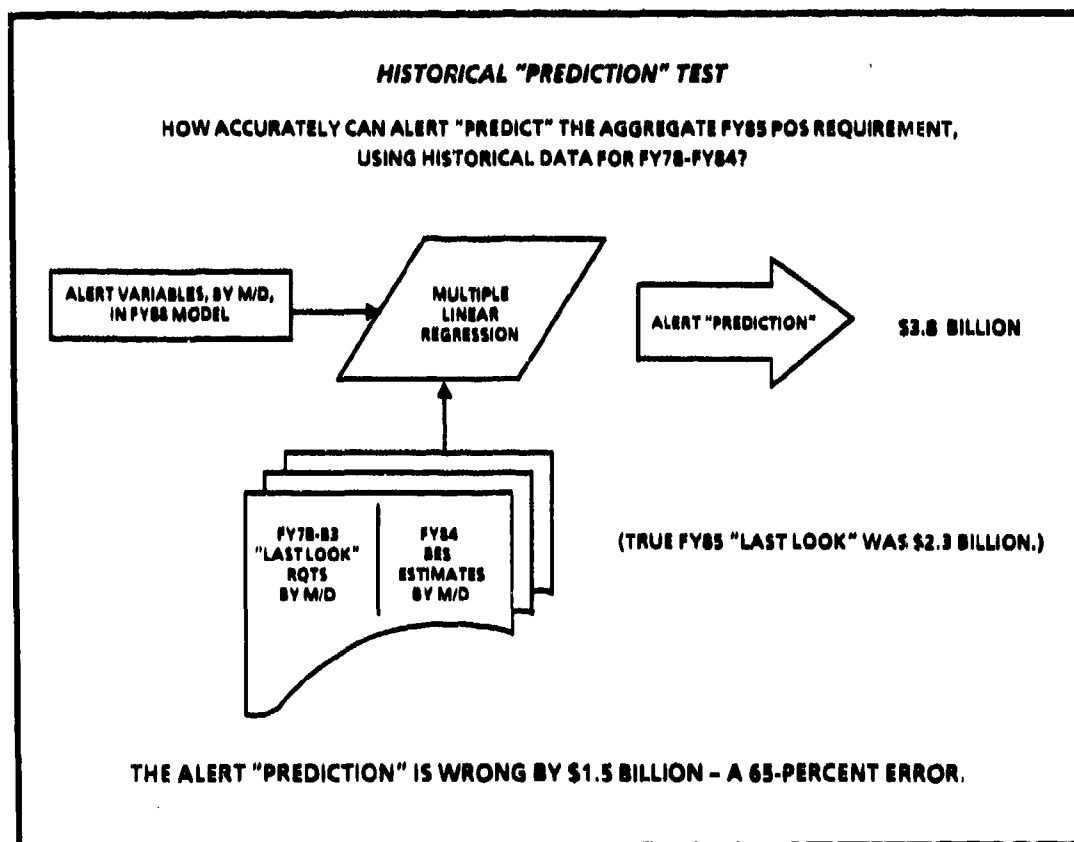
Accuracy Problems

The estimate of the aggregate FY88 POS requirement, the sum of ALERT's 17 system-level estimates for POM 88, is \$2.15 billion. We have just seen that if this is an accurate estimate of the mean aggregate requirement, we can be fairly confident that the actual FY88 requirement will be within \$430 million of that figure. But why should we believe that \$2.15 billion is an accurate estimate? So far, all we have is the *concept* of ALERT, namely, that regression can give us the right answer, using early D041/CSIS estimates and information about age and value of the fleet as inputs. Is there any external, objective way to test ALERT's accuracy?

Because POM 87 was the first POM done officially with ALERT, the first *official* test of ALERT's predictive accuracy will not come until the spring of 1987, when the results of the March 1987 last look will become available. In the

meantime, we can test the model's *potential* accuracy by applying it to "project" a known historical value. In particular, if we apply the ALERT regression methodology to the appropriate historical data for FY78 through FY84, we can see how well ALERT does in projecting the last look at FY85. Figure 4-4 shows the results.

FIGURE 4-4. ALERT's PREDICTIVE ACCURACY



Using the same predictor variables by system as in ALERT's POM 88 equations, but using the data that would have been available at the time (late in FY82, when POM 85 projections were being made), we performed regressions and obtained ALERT-type projections of what the last look FY85 would be. As Figure 4-4 shows, ALERT's projection was \$3.8 billion. The actual FY85 last look

(for the 17 systems considered by ALERT) was \$2.3 billion.⁶ ALERT was wrong by \$1.5 billion — an error of 65 percent.

How can the model have been this wrong? To answer this question, we repeated the experiment, but with a crucial change in the input data. The projection just described used input data that would have been available to ALERT at the time (fall of 1982), when a projection for FY85 was being made. In particular, as the history for FY84, we used an *estimate* from the D041/CSIS/transition system of what the last look would be. In the fall of 1982, ALERT has only a second-look estimate for FY84.⁷ The actual last look for FY84, in aggregate for the 17 systems in ALERT, was \$2.5 billion. In the fall of 1982, however, the D041/CSIS/transition system, taking its second look at FY84, was estimating the FY84 requirement to be \$3.3 billion. When we replaced that estimate with the actual, historical last look for FY84, however, the ALERT procedure yielded an estimate of \$2.54 billion as the aggregate requirement for FY85. This projection is within \$250 million (11 percent) of the actual FY85 last look of \$2.3 billion.

There are negative and positive aspects to this result. On the negative side, the result says that ALERT's reliance on the D041/CSIS/transition system for the last 2 years of history causes the method to be substantially less accurate than it would be otherwise. Unfortunately, the data ALERT needs to be accurate — actual last looks for the 2 years preceding the first POM year — cannot be known with certainty at the time ALERT must make its projections. On the positive side, it says

⁶The total last look at FY85 of \$2.6 billion included \$300 million for the B-1, which is not included among the 17 systems addressed by ALERT. Thus, \$2.3 billion is the correct portion of the FY85 last look to compare with the ALERT projection of \$3.8 billion.

⁷In both tests, we used the actual, historical last look for FY83 as the history for FY83. Strictly speaking, we should have used a fourth-look estimate for FY83, because that is all that would have been available in the fall of 1982. In fact, there was less than a \$100 million difference between the fourth and last looks at FY83. The last look at FY83 was \$3.28 billion. The fourth look was \$3.19 billion.

that if the budgeting system were improved, the accuracy of ALERT forecasts for POMs would probably improve as well.

Stability Problems

It is not likely that ALERT forecasts of a given year's requirement will be stable over time. Successive ALERT forecasts of the FY88 requirement, for example, have been \$5.0 billion (spring 1984), \$3.44 billion (spring 1985), and \$2.15 billion (fall 1985). The \$5.0 billion estimate for FY88 appears in a 1984 description of ALERT prepared for the Deputy Chief of Staff/Materiel Management at AFLC. The \$3.44 billion estimate appears in an April 1985 memorandum from the Comptroller, HQ USAF, to the Comptroller, HQ AFLC. The \$2.15 billion estimate is the sum of 17 system-level ALERT estimates taken directly from ALERT output products prepared in the fall of 1985.

Because these estimates were not all taken from a standardized management report, different levels of management review (adjustments made outside and separate from direct ALERT calculations) may be reflected in these figures. In each case, however, the figures are described as "ALERT" estimates. The fact that management adjustments are present in these different estimates does not change the central point that estimates are subject to massive fluctuations. It does show that management decisions at various levels, at both AFLC and the Air Staff, contribute to the problem of fluctuating estimates, in addition to whatever the ALERT model does. Successive ALERT estimates of the FY87 last look were \$4.5 billion (spring 1984) and \$2.98 billion (spring 1985).

This level of instability is as bad as that exhibited by earlier POM estimating methods (see Figure 2-1 in Chapter 2), which means that ALERT fails to address the main cause of the credibility problem -- fluctuating estimates of the same year's requirement.

Why does ALERT exhibit this instability? Again, the volatile behavior of the budgeting system and its central role in the ALERT methodology are the main reasons. We have already seen how the use of early D041/CSIS/transition estimates as history undercuts ALERT's chances for accuracy. Use of these estimates also contributes to the instability problem. When ALERT was used to make projections for POM 87, for example, second-look estimates (totaling \$2.7 billion) served as the historical FY86 last looks for the 17 systems in ALERT. A year later, for the POM 88 projections, ALERT was using fourth looks at FY86 (totaling \$2.0 billion) as the FY86 last looks. This \$700 million drop in the "historical" data is one reason for the change in the ALERT estimate for FY88, from \$3.44 billion in POM 87 to \$2.15 billion in POM 88.

Another reason the FY88 estimate changed is that the FY88 forecasting equations changed. The most fundamental change was the introduction of the June 1985 D041/CSIS deficit as a predictor variable for FY88. In POM 87, FY88 was one of the four POM outyears, and no D041/CSIS variable applied. In POM 88, FY88 was the first POM year, and the June 1985 D041/CSIS variable became the key predictor variable. In general, when a year becomes the first POM year after having been a POM outyear, there is likely to be a significant change in the ALERT estimate.

If the June D041/CSIS estimate is not used as the key predictor variable for the first POM year, ALERT becomes similar to the POSSEM model developed by the Air Staff. POSSEM basically uses only age and value of the fleet as predictor variables. In this case, as demonstrated by the reception the POSSEM model received, questions about the conceptual validity and reliability of the model become major obstacles to its acceptance.

CAN OTHER FORECASTING METHODS DO BETTER?

Lack of accuracy and stability in its estimates will prevent ALERT from solving the credibility problem for spares. Can other forecasting methods do better? The test of whether other methods can do better is *not* whether their concept and approach sound better than ALERT's. The test is whether or not they will provide reasonably stable and accurate estimates of future spares requirements for POMs.

In this section, we take a brief look at alternatives to ALERT. Our conclusion is that until the D041/CSIS/transition budgeting system is improved, no POM forecasting method can do any better than ALERT.

The Peacetime Operating Stocks Spares Estimating Model (POSSEM)

POSSEM is a multilinear regression model that was developed by the Comptroller of the Air Force (HQ USAF/AC). POSSEM preceded ALERT and was used by the Air Force for POM 85 and POM 86 projections. The main difference between POSSEM and ALERT is that POSSEM does not include an early D041/CSIS estimate in its set of predictor variables, but relies solely upon value and age of the fleet and (for some systems) projected utilization rates.

Another important difference between POSSEM and ALERT is that POSSEM does not employ earlier D041/CSIS/transition estimates as history for the 2 years preceding the first POM year. Although both POSSEM and ALERT attempt to project what last-look values will be, POSSEM simply accepts the 2-year gap between historical last looks and the first POM year, rather than use estimates of the final values for those 2 years.

The fact that D041/CSIS/transition products are not central to the POSSEM approach — either as predictor variables or as history substitutes — means that POSSEM estimates are likely to exhibit greater stability over time than ALERT estimates. This, in fact, has been true of POSSEM estimates. But not using D041/CSIS inputs hinders POSSEM's acceptance on conceptual grounds. Failure to

tie in D041/CSIS projections opens POSSEM to the complaint that it will not be responsive enough to changes in the force structure and flying-hour program — traditionally viewed as drivers of future spares requirements. (This complaint about POSSEM was raised by AFLC and was the primary motivation for ALERT's development.) Adjusting POSSEM outputs after the fact to reflect such changes is equivalent to the old cost-per-flying-hour method and will not solve the problem.

Even more important than the conceptual questions about POSSEM is the question of whether age and value of the fleet by themselves can provide sufficiently accurate estimates. As a first test, we obtained the POSSEM estimate for FY85, as it appeared in POSSEM documentation prepared in January 1983 by the Air Staff. (POM 85, which was submitted in May 1983, was prepared using POSSEM.)⁸ The POSSEM estimate for FY85 was \$3.4 billion, plus an estimate of \$705 million in unfunded carry-over, for a total of \$4.1 billion. The true last look at FY85 was \$2.3 billion. POSSEM missed by \$1.8 billion — a 78-percent error.

As a second test (motivated by the fact that a programming error was discovered in POSSEM in April 1985, which cast doubt on earlier projections), we did our own projection of FY85, as we did for ALERT, but this time following the POSSEM approach. Using historical last looks by system for the years FY78 through FY82 as the observed values of the dependent variable, regressions were done using value and the reciprocal of age as the two independent variables for each of the 17 systems of interest. From the derived relations, we projected the FY85 last look, using the value and age amounts that applied in FY85. When the results were added, the aggregate projection for FY85 was \$5.5 billion. The true FY85 last look was \$2.3 billion. Thus, in our test of the POSSEM approach, the method missed the

⁸Colonel Donald G. Kane, Director of Cost and Management Analysis (HQ USAF/ACM), *Study of Air Force Aircraft Replenishment Spare Requirements*, (Washington, D.C.: HQ USAF/ACM, January 1983).

desired answer by \$3.2 billion — a 140-percent error. The Appendix gives additional details about the test.

On the basis of these results, combined with the POSSEM's problems in gaining conceptual acceptance, we do not think POSSEM or POSSEM variants would be any more successful than ALERT in solving the credibility problem for spares requirements.

MACROSTRAT

MACROSTRAT represents a totally different approach to the spares forecasting problem for POMs. The basic idea is to define an average component for each weapon system in terms of average pipeline factors: failure rates, repair times, and condemnation rates. Then, for this average item, a deterministic calculation is performed to compute unit requirements for the budget year and the POM years. The unit price for the item is not the average unit price across all items used on the system, but rather is set so that the budget-year requirement for the item times this price is equal to the computed D041/CSIS/transition budget requirement across all items for the system. MACROSTRAT computes the dollar requirement for the POM by multiplying the unit requirement for each POM year by this "calibrated" unit price.

The MACROSTRAT approach does distinguish between net and gross requirements and, for that reason, is an improvement over cost-per-flying-hour methods. Obviously, however, changes in item factors from year to year in the D041 data base, including changes in the value of the calibrated unit price, will influence MACROSTRAT forecasts. Thus, in its own way, MACROSTRAT is as dependent on the underlying budgeting system as ALERT.

Quantitative tests of the MACROSTRAT approach were not done for this study. MACROSTRAT-like approaches, therefore, cannot be categorically dismissed as having no promise. It is possible that such approaches, perhaps tailored to

different categories of spare parts (e.g., avionics, hydraulics, and mechanical) are worth exploring. But the Air Force must keep in mind that the budgeting system itself is the root of the spares forecasting problem, and efforts that focus on POM forecasting run the risk of diverting needed attention and resources from the underlying budgeting problem.

How the Army and Navy Do It

Because of the attention Air Force problems have received, the perception may be that the Air Force is the only Service having difficulties forecasting aircraft spares requirements. In fact, both the Army and the Navy have had similar problems.

The Army, using the Requirements Determination and Execution System (RD/ES) within the Army Materiel Command's Commodity Command Standard System (CCSS), computes spares requirements with item-specific, bottom-up, D041-like methods. A key feature distinguishing the Army from the Air Force is that the Army pushes item calculations through the entire POM period. Like the Air Force, the Army makes transition adjustments to computed requirements to obtain the final, official requirement.

The item-specific, bottom-up approach has not made the Army more successful than the Air Force in forecasting spares requirements. Between FY80 and FY84, the Army's total requirement for aircraft spares (initial provisioning, replenishment, and war reserve) increased substantially -- from approximately \$70 million to more than \$600 million. Like the Air Force, the Army discovered that its spares requirements system was failing to give reliable and accurate forecasts of future requirements. The similarity of the Army's and Air Force's problems is

indicated by the fact that in the fall of 1983, the Army commissioned a major study⁹ of aircraft spare parts requirements forecasting, a study very similar in spirit to the CORONA REQUIRE study by the Air Force a year earlier.

A finding of the Army study was that POM and budget forecasts of a given year's requirement tended to be very different from actual "end-of-year" requirements. As an example, the study cites POM and budget forecasts for FY83 that "amounted to only 44 percent and 48 percent respectively of the eventual FY83 end-of-year actual requirement." The study goes on to state that "forecast errors of this magnitude clearly exceed that which should be considered acceptable for budget forecasting purposes."

The principal recommendation of the Army study was:

The Army, specifically HQDA, should make a conscious decision that the status quo in the aircraft spares program and budget requirements determination process is no longer acceptable and commit resources to initiate and sustain both short-term and long-term corrective actions.

In its continuing efforts to solve these problems, the Army has not attempted to develop alternative POM forecasting methods to replace its item-specific approach. Instead, mainly as a result of influence and control exerted by the Vice Chief of Staff (HQDA), the Army has recognized the need for stability in requirements estimates and has instituted management and review procedures at Headquarters to enforce greater discipline in the POM-to-budget-to-execution process for spares.

Like the Air Force and the Army, the Navy has seen its requirements for aircraft spares grow in recent years. Also like the Air Force and Army, the Navy's has a bottom-up, item-specific computational system for computing budget and

⁹Fred J. Lokay, et al., *Aircraft Spare Parts Requirements Forecasting Study*, Final Report, Report 1404-04-84-CR, prepared for the Office of the Deputy Chief of Staff (Research, Development and Acquisition), [Headquarters, Department of the Army (HQDA): General Research Corporation], October 1984.

execution requirements for spares — the Cyclic Forecasting and Levels Program (D01), which is embedded in the Navy's mechanized Uniform Inventory Control Program (UICP) system. What distinguishes the Navy's approach is the greater role that transition adjustments play in determining final requirements — after item-specific computations have been completed.

The major role played in the final requirement by program-related transition adjustments makes the Navy's POM forecasting problem somewhat different in character than the Air Force's. Given the greater emphasis on program-related requirements, POM "forecasts" in the Navy tend to be more statements of planned programs than predictions of what the item-specific requirements system will produce. These "forecasts" are "successful" to the extent that the Navy sticks to its plan — either by proceeding with planned programs or by reallocating resources (without changing the total) as plans change.

The structure of a typical Navy budget in comparison with an Air Force budget illustrates the greater role played by program-type requirements in the Navy. In the Navy's aircraft spares replenishment budget request for FY84, line 18 of the P-18 transition document shows the net FY84 requirement calculated by the Navy's item-specific computational and stratification system to be \$1.48 billion. There are then 32 different columns for *additional* positive and negative adjustments to stratification results, with a final net requirement statement of \$4.07 billion.

These adjustments include: \$622.5 million in initial spares requirements not included in stratification (the Navy includes certain initial spares requirements in the replenishment request), \$901.5 million in follow-on requirements "not in stratification" (NIS), \$161.4 million in Aviation Coordinated Allowance List (AVCAL) maintenance, and \$82.3 million in F-18 replenishment NIS. These program-type adjustments are in addition to standard adjustments for such items as

carry-over from prior years (\$709.5 million) and price redetermination and escalation (\$87.1 million).

In comparison, the Air Force budget request for FY84 shows a computed D041/CSIS deficit of \$1.37 billion, which, after transition adjustments, becomes \$3.34 billion. Although the magnitude of the change is comparable with that in the Navy budget, the reasons are different. The difference in the Air Force budget is driven by: \$261.3 million in scrub adjustments; \$260.1 million in new, additive programs; \$619.3 million due to price redetermination; and \$904.5 million in unfunded carry-over requirements. Although program-type adjustments and additives contribute, they are not as influential in the Air Force budget as in the Navy budget.

Of course, the Navy's greater reliance on program-type requirements does not in itself guarantee that the Navy's total requirements will remain stable from POM to budget to execution. For that to happen, planning and funding discipline must be enforced. Although there are no formal mechanisms in the Navy requirements system that force program managers to make tradeoffs, the Navy, like the Army, has developed operating procedures that promote this discipline. Conversations with former Naval Supply System Command (NAVSUP) personnel indicate that, in the early 1980's, senior NAVSUP management (like senior Army management) began insisting upon consistency over time in the programming, budgeting, and execution process for spares.

The Navy does have a macro-level forecasting procedure for predicting the dollar value of the recurring-demand-based portion of spares requirements in the POM years. Called the Value of Operating Aircraft (VOAC) method, the Navy multiplies the dollar value of the recurring-demand-based portion of the current (e.g., budget) requirement by the ratio of the dollar value of operating aircraft in the POM years to the current dollar value of operating aircraft. Although not a regression,

the VOAC method is similar in concept to ALERT and POSSEM in relating spares requirements to the value of aircraft. Because recurring-demand-based requirements represent only a small portion of the final requirement, however, the stability and predictive accuracy of the Navy's method are not as visible or as crucial to the Navy's spares program as to the Air Force's. With ALERT, the Air Force attempts to project the *entire* requirement, including program-related requirements. The Navy separates program-related requirements, defends them as such, and follows up with deliberate management review that is aimed specifically at preserving reasonable consistency in the spares requirement over time.

In effect, the Navy's approach recognizes that attempts to forecast program-type requirements, which represent a substantial portion of the total requirement, are futile. Program requirements are requirements that will be determined largely by future management decisions -- decisions that, over POM forecasting horizons, cannot be foreseen by technical forecasting models.

Neither the Army nor the Navy, therefore, has developed a technical forecasting tool that solves the spares forecasting problem for POMs. Instead, both Services have reacted to the problem with management initiatives designed to yield greater consistency in the programming, budgeting, and execution process.

Other Methods?

Is it possible that some other approach, different from the ones we have discussed, might work? Regardless of what technique is used to make POM forecasts, the same basic question must be asked: Will it solve the credibility problem for spares?

We have argued that bad *budget* forecasts, not POM forecasts, are the main cause of the credibility problem. No POM forecasting model, therefore, can solve the credibility problem. Regardless of how *POM* forecasts are developed, DoD policy and established procedures [such as Central Secondary *Item* Stratification

(CSIS)] are such that *budgets* will continue to be put together with item-specific computational systems. As long as projections made with those systems are flawed, the credibility problem will persist.

The positive side is that if the budgeting system is improved, POM forecasts will improve. The results presented earlier, showing that the ALERT approach works reasonably well when real history is used instead of estimates, suggest this is true.

5. MANAGEMENT, NOT FORECASTING, IS THE ANSWER

THE MANAGEMENT APPROACH

We have seen that, since the early 1980's, neither the D041/CSIS/transition system nor POM forecasting models built around that system have been able to provide the Air Force with reliable estimates of future spares requirements. With continuing change in the overall Air Force program, this problem is likely to persist. No matter what their form, forecasting techniques by themselves can never guarantee the correctness of statements of future spares requirements.

To solve this problem, the Air Force needs to move beyond reliance on forecasting alone and recognize that *control* of the aggregate requirement, through management, is also necessary to ensure consistency from POM to budget to execution. By instituting procedures deliberately aimed at stabilizing the total requirement, the Air Force can achieve through management what it has been unable to accomplish through forecasting: credible, defensible statements of future spares requirements.

For both AFLC and the Air Staff, the idea that the requirements system should be used to manage and control requirements, in addition to computing them, represents a new view of the system. In the traditional view, the requirement — whether it is today's execution requirement or tomorrow's budget and POM — is whatever the requirements system says it is. The new view recognizes that budgets and POMs reflect human judgments and decisions, which may be *informed* by computer-based estimates but cannot and should not be *determined* by them. Budgets are, after all, just that — *budgets*; changes in computed material requirements are not always automatically sufficient to justify departing from the funding constraints that budgets impose. Until the Air Force recognizes this and begins to exercise better

management control of the many decisions that go into the requirement, spares requirements will continue to be troublesome.

The challenge, of course, is to exercise control of the aggregate funding requirement without sacrificing the flexibility needed to deal with changing material requirements. To meet this challenge, the Air Staff should fully acknowledge that material requirements will always change from POM to budget to execution and should be prepared to explain these changes to decision-makers in the programming and budgeting process. AFLC, for its part, should be prepared to use the requirements system as an *allocation* tool, to reallocate resources as necessary when changes occur, so that the total funding requirement can be held reasonably stable.

Two prerequisites apply if AFLC and the Air Staff are to do this: Managers at all levels must be able to obtain accurate, up-to-date information on spares requirements by weapon system, and AFLC and the Air Staff need to improve their understanding of each other's jobs.

Information by weapon system is important because managers need to know when system requirements have changed and how to reallocate resources to deal with that change. Better understanding between AFLC and the Air Staff is important because of the different demands the two organizations place on the requirements system. AFLC needs a system that tracks changing requirements; the Air Staff needs one that produces stable POM and budget estimates. Unless the two organizations recognize this fact and work together, it will be very difficult for any requirements system to meet their conflicting demands.

THE REQUIREMENTS DATA BANK PROJECT

Providing information on spares requirements by weapon system is one of the central goals of the Requirements Data Bank (RDB) project now underway at AFLC. The RDB project represents a significant AFLC effort to modernize, integrate, and improve peacetime and wartime requirements and execution systems in the Air

Force for reparable and consumable secondary items, support equipment, and engines. The RDB project has two primary objectives:

1. To develop forecasts of logistics resources required to achieve specific weapon-system readiness and sustainability goals throughout the POM period
2. To develop a logistics operations and budget execution system to achieve the weapon-system support goals that have been resourced in the POM process.¹

Given the importance of *managing* the aggregate spares requirement, we recommend the Air Force adopt the following as an integral part of the second objective:

The RDB will serve as a tool enabling logistics managers to review, control, and prioritize spares requirements as they develop, and reallocate resources as necessary. This will ensure system-level flexibility and responsiveness for purposes of execution, while at the same time making stability at the aggregate level possible for purposes of programming and budgeting.

The RDB project is aimed at improving the content and accessibility of the spares data base through development of improved computational and data processing capabilities. Improved capabilities are only half the story, however. *Unless the Air Force takes advantage of the RDB's new capabilities and uses them to manage spares requirements — not just compute and report them — the RDB will be no more successful than existing systems have been in solving the credibility problem for spares.*

AFLC AND THE AIR STAFF

AFLC and the Air Staff have different jobs. AFLC's prime job is execution. Most of AFLC's attention and effort is spent preparing the short-term plans and

¹The Air Force Requirements Data Bank (RDB): Motivation, Objectives and Development Strategy, Colonel Robert S. Tripp, RDB Program Manager, Logistics Management Systems Center, Air Force Logistics Command; and Ms. Diann Lawson, Assistant for Requirements Development, Directorate of Materiel Requirements (Wright-Patterson AFB, Ohio: Headquarters, Air Force Logistics Command, March 1986).

making the day-to-day procurement, repair, and transportation decisions necessary to provide the Air Force with continuing logistics support. To do that job well, AFLC needs a dynamic requirements system that tracks and responds to change.

Air Staff offices concerned with spares requirements, on the other hand, have the task of presenting and defending programs and budgets in the annual Planning, Programming, and Budgeting System (PPBS) process. To do this, the Air Staff relies on the requirements system to provide stable and accurate estimates of future requirements. If responsiveness in the AFLC system causes budget estimates to change, the Air Staff's job becomes very difficult. Rather than changing the budget, it is better to use system responsiveness to reallocate. Application of the requirements system to the task of monitoring and controlling requirements, in addition to computing them, is necessary for the Air Force to live within its budget.

For the Air Staff and AFLC to work together, therefore, two points are important. The Air Staff must fully acknowledge that requirements for recoverables are inherently subject to change and that AFLC needs a system that tracks this change to do a good job in execution. AFLC, for its part, should recognize that the Air Staff needs reasonably stable estimates of future requirements if spares funding requests are to be defended successfully in the programming and budgeting process. Otherwise, it will be very difficult for AFLC and the Air Staff to set up the joint management mechanisms required for effective use of the RDB.

THE STOCK-FUNDING OPTION

For other reasons, apart from the POM forecasting problem, the Air Force is considering the possibility of stock funding as an alternative way to finance inventories of reparable spares. Aviation reparables became stock-funded in the Navy in FY85, and both the Air Force and Army are studying the possibility of following suit -- partly in response to Congressional suggestions. If reparables are

stock-funded in the Air Force, there are several implications for the POM forecasting problem.

Under the present system, the Air Force's supply system replenishes, renews, and builds its stocks of reparable spares with procurement funds appropriated each year by Congress. These spares are issued, at no charge, to users at Air Force bases and depots as needed. Under stock funding, the supply system would continue to draw on appropriated funds to build new inventories to support force growth, modernization, and readiness improvements (in the stock fund this is called "inventory augmentation"), but the system would begin using nonappropriated funds from a revolving cash account, the Air Force stock fund, to meet replenishment requirements (e.g., replacement of condemnations and requirements caused by churn).

POMs are not required or submitted for stock-fund peacetime replenishment requirements — only budgets are submitted. Thus, if reparables are stock-funded, it will no longer be necessary to make POM forecasts of peacetime replenishment requirements for spares. This is one of the reasons the Navy adopted stock funding for reparables.

As noted above, though POMs are not required under stock funding, budgets still must be prepared. Even here, however, there is an important difference. Stock-fund replenishment budgets are not subject to the Congressional review that is applied to appropriated budgets (such as Budget Program 1500 for spares in the Air Force). Final review and approval authority for stock-fund replenishment budgets lies with the OSD Comptroller and the Office of Management and Budget. This makes the approval and adjustment process easier for stock-fund budgets than for appropriated budgets.

Under stock funding, POM forecasts would still be required for inventory augmentation requirements. Most of these requirements, however, are program-based rather than recurring-demand-based requirements. POM "forecasts" of inventory

augmentation requirements, therefore, could be presented as statements of specific program requirements (the way the Navy does it), rather than as forecasts (as ALERT presents them).

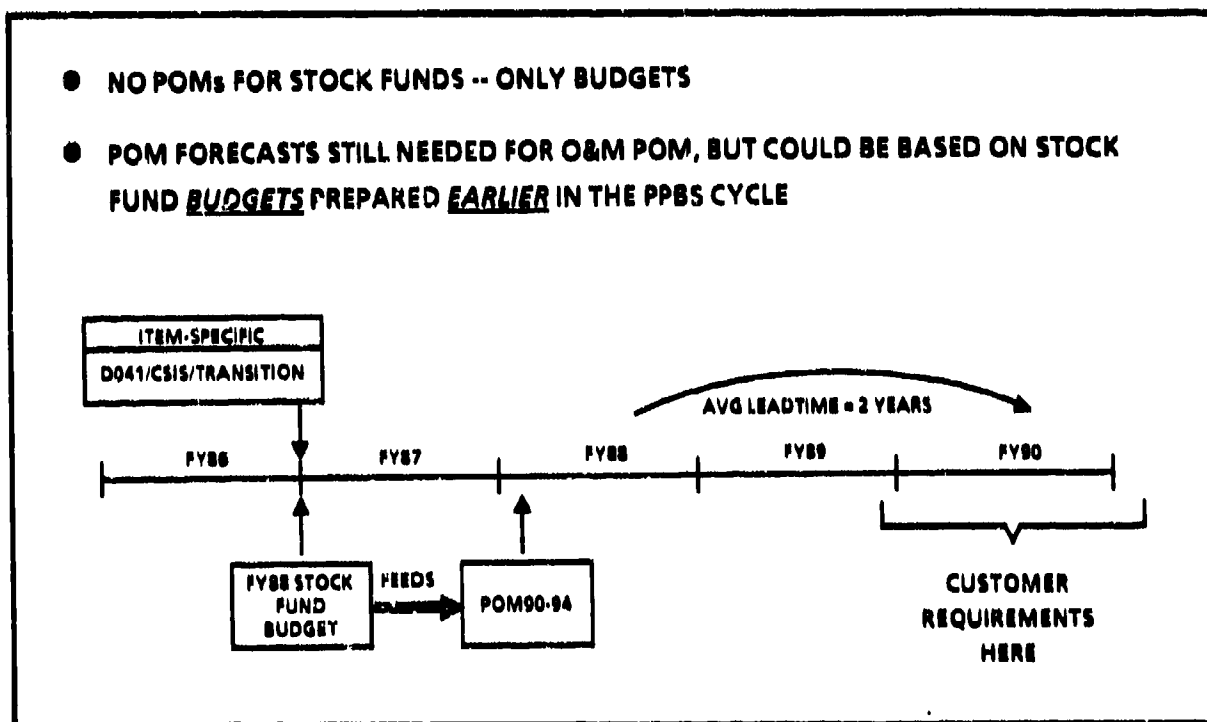
Given the difficulty of projecting program-type requirements with historically based forecasting models, the fact that stock funding would force the Air Force to distinguish between recurring-demand-based requirements and program-based augmentation requirements is a good thing. With improved visibility of what is program-based and what is not (a place where the RDB should help), it would be easier to exercise management control of requirements. The distinction would also make it easier to defend requirements in the programming and budgeting process — both within the Air Force and before OSD and Congress.

Although stock funding eliminates one POM forecasting problem, it creates another. The stock fund replenishes itself through sales of stock-funded material to Air Force and other DoD and government customers, who generally pay for their purchases with funds from either appropriated Operations and Maintenance (O&M) accounts, or — in the case of depot customers — industrial fund accounts. POMs must be prepared for many of these accounts. Thus, under stock funding of reparable, it will be necessary to make POM forecasts of the funding required in *customer* accounts (e.g., the O&M appropriation) to enable customers to buy the spares they need from the stock fund.

However, because customers need funding when their *material* requirements exist, POM estimates for customer accounts could be made *later* than present POM estimates for appropriated procurement accounts. This means that POM estimates can be made closer in time to the point when material requirements exist. Shortening the POM forecasting horizon in this way improves the chances of correctly predicting requirements and correctly allocating resources to meet them. Figure 5-1

illustrates the shortening effect in relation to FY88, if reparables were already stock-funded.

FIGURE 5-1. POM FORECASTING IF REPARABLES ARE STOCK-FUNDED



The time line in Figure 5-1 is the same as that in Figure 2-2 in Chapter 2. As noted in Chapter 2, under the present system, the POM forecast for FY88 must be made in the fall of 1985. Funding requirements in FY88 correspond to material requirements a procurement leadtime later. Since the average procurement lead-time for reparables is 2 years, FY88 funding requirements correspond to material requirements in FY90.

Figure 5-1 shows that under stock funding, there is no peacetime replenishment POM required for FY88; the first POM that must be prepared in connection with FY90 material requirements is POM 90, which is a full procurement leadtime closer to FY90 than POM 88. The first forecast of FY88 funding requirements that

must be prepared is the FY88 budget. Furthermore, the PPBS calendar is such that the POM 90 forecast is submitted *after* the FY88 stock-fund budget has been assembled. This means that if the FY88 budget is a good forecast of what the stock fund needs to place on order in FY88 to meet material requirements in FY90, POM 90 can use the FY88 budget as the basis for its estimate of customer funding requirements in FY90.

For the outyears of POM 90 (FY91 through FY94), the POM forecasting problem for customer accounts under stock funding is very similar to the one under the present system. Thus, stock funding does not eliminate the need for continued work on long-range forecasting techniques for spares. In terms of numbers that have the most effect on resource allocation in the Pentagon, however, estimates for the POM outyears are not as important as those for the first POM year. If forecasts for the first POM year can be improved under stock funding, it should be possible to make better outyear forecasts, perhaps with ALERT or other, simpler methods.

The final and most important point about stock funding is this: *Stock funding affects only the POM forecasting problem.* Stock funding does not alter the fact that there is a budget forecasting problem, or reduce its severity. For example, if reparable were already stock-funded in 1986, no replenishment POM would have been necessary, but the Air Force would still have had to make a *budget* estimate of the FY88 funding requirement (see Figure 5-1). The only advantage to be gained from stock funding is that by reducing the size and difficulty of the POM forecasting problem, the Air Force would be able to apply more attention and resources to the budgeting problem.

SUMMARY

With the advent of the RDB and the possibility that reparable will become stock-funded, the spares forecasting problem in the Air Force will become easier. The RDB will provide information that will enable the Air Force to better

understand how and why spares requirements change, and this will help the Air Force make better forecasts. Stock funding of reparables, if it happens, will shorten forecasting leadtimes and reduce the size and difficulty of the POM problem, allowing the Air Force to concentrate on the budget forecasting problem for spares.

In any case, successful spares forecasting is more likely to be achieved through better cooperation between AFLC and the Air Staff in developing, prioritizing, and controlling spares requirements than through development of increasingly more complicated forecasting techniques.

APPENDIX

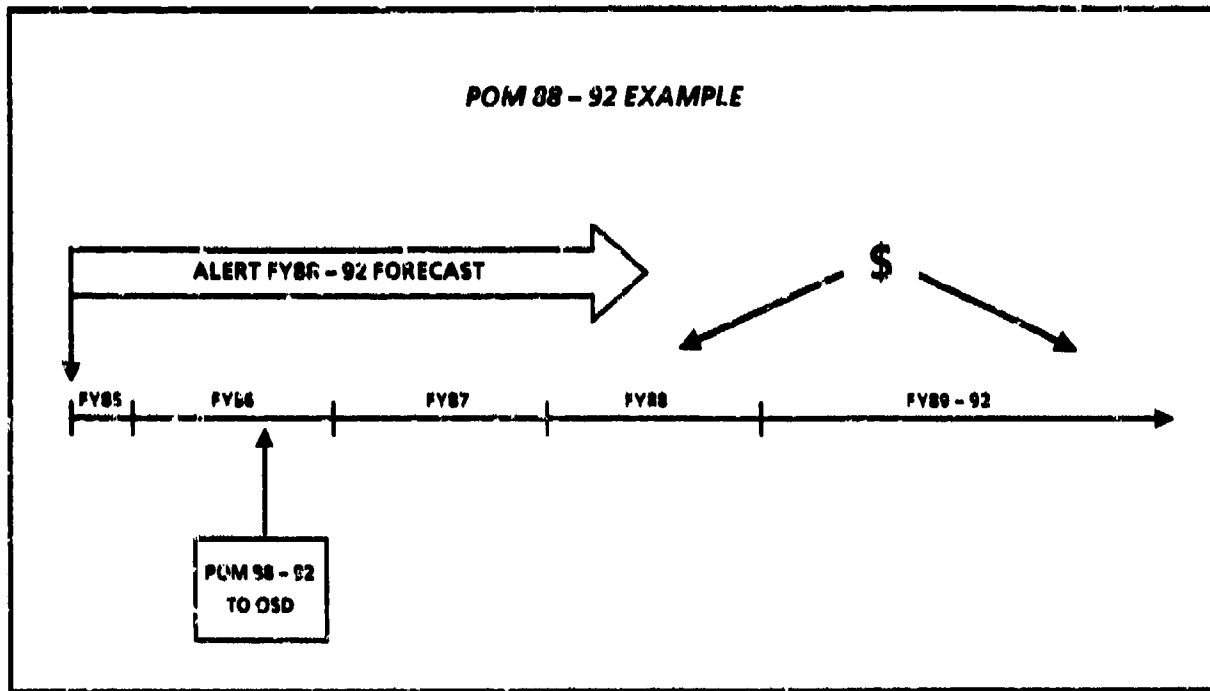
THE D041 CALENDAR AND FURTHER DETAILS ON THE ANALYSES OF ALERT AND POSSEM

This appendix presents some additional technical details concerning the D041 calendar and additional explanation of the statistical analyses done of the ALERT and POSSEM models.

The meaning of the terms CY, AY, BY, and EY (current year, apportionment year, budget year, and extended year) in conjunction with the D041 system can be understood using Figure A-1. In the forecasting timeline in Figure A-1, the last quarter of FY85 is the CY, and the years FY86, FY87, and FY88 are the AY, BY, and EY, respectively. The June 1985 D041/CSIS computation is the first item-level computation that can see FY88 funding requirements. This is illustrated by the vertical arrow on the left side of Figure A-1, which indicates that the June 1985 D041/CSIS computation serves as input to the ALERT projection for POM 88. Note that the June computation is not scrubbed (i.e., subjected to transition). The September 1985 computation is scrubbed and sees FY88, but its products are not available to ALERT in time to meet AFLC's fall deadline for delivering POM estimates to the Air Staff.

Note also that there is no D041/CSIS product that provides information on funding requirements in the 4 outyears of the POM. All of those years are beyond the extended year, and the D041/CSIS system simply does not look that far ahead for *funding* requirements. This is one reason why AFLC has no choice but to seek *macro* (i.e., non-item-specific) projection methods for POMs. Another, more important reason is that item-specific projections are not reliable that far into the future -- as discussed in Chapter 3.

FIGURE A-1. THE FORECASTING TIMELINE



ALERT does not employ regression at the aggregate level. Aggregate estimates are obtained by addition of the 17 estimates obtained from ALERT's system-level regressions. ALERT developers have suggested that the model's aggregate precision is better than its precision at the system level, but they have presented no quantitative proof. The aggregate prediction intervals presented in Chapter 4 show that, indeed, ALERT's aggregate precision is better. The following explains how aggregate prediction intervals were computed.

Each system-level regression produces an estimated mean value for the system's requirement and a coefficient of determination (r^2) that measures the strength of the regression relationship. The estimated mean is the mean for a t-distribution, with a variance that can be computed from the r^2 value, and degrees of freedom based on the number of variables used in the regression. Prediction intervals at the system level, like the one shown for the C-5 in Figure 4-3, are confidence intervals in these t-distributions.

From the individual distributions, aggregate prediction intervals can be constructed through simulation. The intervals cited in Chapter 4 were constructed by making 1,000 draws from each of the 17 t-distributions defined in ALERT's FY88 projections for POM 88. Draws were made using the STATGRAPHICS (STSC Corporation, Rockville, Maryland) statistical package operating on an IBM personal computer. Adding the results of the draws across the 17 systems gave 1,000 values from the unknown, composite distribution of the aggregate requirement. Sorted, these 1,000 values define an empirical histogram of the aggregate distribution. Aggregate prediction intervals were obtained from the sorted list by counting the number of values between the bounds of the desired interval and dividing by 1,000 to obtain the confidence level.

Regarding the test of the POSSEM approach described in Chapter 4, there are technical problems in the POSSEM method that require special treatment. In particular, for the system category of common components, the age and value of the "fleet" are not well-defined, and, for the system of "other systems," age is not well-defined. Following the POSSEM approach in these two cases, regressions were performed only against value for "other system." For common components, system-by-system regressions were performed, using common component percentages of each weapon system's requirement as the value of the dependent variable. The common component breakout percentages were taken from POSSEM documentation.

In the simulated POSSEM projections, the predicted values for the C-5 and the F-15 each exceeded by more than \$1.0 billion the actual "last look" for those systems. If we remove these two systems from consideration, the actual last look becomes \$2.16 billion, and the simulated POSSEM projection is \$3.24 billion. The POSSEM approach still makes a \$1.21 billion (51 percent) error.

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<p>Since the early 1980's, spending by the U.S. Air Force for reparable spares for peacetime use has exceeded \$2.0 billion per year. In the same period, Air Force estimates of future spares requirements have come under greater critical scrutiny, both within and outside the Air Force. The Air Force Logistics Command (AFLC) has developed a regression-based forecasting model, ALERT (Air Logistics Early Requirements Technique), to improve POM (Program Objective Memorandum) estimates of future funding requirements for spares.</p> <p>ALERT predicts the output of the Air Force's budgeting and execution system for spares, the "D041" system. To make its predictions, ALERT relies heavily on early D041 estimates, supplemented by age and value of the fleet data by weapon system.</p> <p>Volatility in the underlying D041 system, in the form of fluctuating estimates for the same year, prevents ALERT from being able to make stable, accurate forecasts for POMs. ALERT also has conceptual problems, and its precision at the weapon-system level is poor. The conclusion is that ALERT will not solve the Air Force's credibility problem regarding spares.</p> <p>To solve the problem, the requirements system should be used to track and control requirements for spares - not just compute them. A properly designed system will allow Air Force managers to reallocate dollar resources by weapon system, so that the overall funding request (the budget) can be held stable, even when material requirements change. In this way, the Air Force can achieve through management what it cannot achieve through forecasting alone: stable, defensible spares budgets.</p>				
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